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ABSTRACT

This document contains the four volumes of an Air Force correspondence course in telephone equipment installation and repair. Each volume consists of student learning objectives, information, exercises, and answers to exercises; a volume review exercise is included for each volume. The first volume includes information about career field duties and responsibilities, introduction to management and supervision, security, fundamentals of electricity, basic electronic circuits, and telephone fundamentals. The second volume continues with the common-battery telephone system features. It reviews the basic principles of central office switching, the station equipment, maintenance and inspection, records, wire maintenance safety, and technical orders. The third volume reviews telephone installation principles including telephone station planning, installation work practices, terminal to telephone wiring, station termination and testing, and prevention maintenance and station trouble isolation. The final volume describes the varied uses of telephone communication systems and operating principles of exemplary equipment. At the end of this volume is a glossary; also included are seven schematic foldouts that are printed separately as three supplements. (KC)

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ED272705

TELEPHONE EQUIPMENT INSTALLATION AND REPAIR SPECIALIST (AFSC 36254)

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3	VOL	VOL 1, Introduction to the Career Field	36254 01 8102	
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5	VOL	VOL 2, Telephone Construction and Repair	36254 02 8012	
6	VRE	VOLUME REVIEW EXERCISE (VOL 2)	36254 02 23	36254 02 23
7	VOL	VOL 3, Substation Installation	36254 03 8102	
8	VRE	VOLUME REVIEW EXERCISE (VOL 3)	36254 03 22	36254 03 22
9	VOL	VOL 4, Key Telephone Systems	36254 04 8102	
10	SUPP	SUPPLEMENTARY MATERIAL (VOL 4) (Foldouts 1, 2, 4, 6 and 7)	36254 04 S01 8102	
11	SUPP	SUPPLEMENTARY MATERIAL (VOL 4) (Foldout 3)	36254 04 S02 8102	
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1. CHANGES FOR THE TEXT: VOLUME 2

a. Page 6, col 1, line 18 fr bot: Change "206" to "204."

b. Page 60, answer 215-3: Change "12 (Six open and six closed periods.)" to "4 interruptions."

2. CHANGE FOR THE VOLUME REVIEW EXERCISE: VOLUME 1

The following questions are no longer scored and need not be answered: 13, 15, 38, 39, 55, 57 and 64.

3. CHANGES FOR THE VOLUME REVIEW EXERCISE: VOLUME 2

a. Page 3, question 7, choice a: Change "officer" to "office."

b. Page 13, question 75, choice a: Change "AFM" to "AFR."

c. The following questions are no longer scored and need not be answered: 17, 21 and 58.

4. CHANGES FOR THE VOLUME REVIEW EXERCISE: VOLUME 4

a. Page 15, question 87: In the stem of the question, change "J53033M" to "J53033B."

b. Page 17, question 100: In the stem of the question, change "3-11" to "6-11." Question 102: In the stem of the question, change "switch 2 to operate" to "the ring side of switch 2 to transmit voice signals."

c. The following questions are no longer scored and need not be answered: 20, 41 and 105.

36254 01 8102

CDC 36254

TELEPHONE EQUIPMENT INSTALLATION AND REPAIR SPECIALIST

(AFSC 36254)

Volume 1

Introduction to the Career Field

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

AN EFFICIENT telephone equipment installation and repair specialist understands the theory of electrical and telephone circuitry and the normal functions of telephone station equipment. This knowledge permits rapid analysis of probable troubles.

The purpose of this CDC is to increase your knowledge about your career field. Use it in conjunction with your on-the-job training to prepare yourself to undertake more complex tasks. You will find that these complex tasks often consist of many simple duties which are not difficult to complete. This dual-channel (CDC and learn-by-doing) training can be done while you are helping your organization to perform its mission.

This volume is the first of four volumes. It includes information about career field duties and responsibilities, the Specialty Training Standard (STS), prerequisite qualifications for progression, fundamentals of management and supervision, and security. Further, it has an explanation on electrical fundamentals and trouble analysis. Fundamentals of telephone are also explained.

Completion of this volume aids in fulfilling the theory and fundamental knowledge required for AFSC 36254. The total training requirement includes further development through the Job Proficienty Guide (JPG) for the specific equipment and duties of your particular assignment.

Code numbers appearing on figures are for preparing agency identification only and should be of no concern to the student.

Direct your questions or comments relating to the accuracy or currency of this volume to the course author: 3750 TCHTG/TTOXU, ATTN: Mr. Paul G. Mercer, Sheppard AFB, TX 76311. If you need an immediate response, call the author, AUTOVON 736-2088, between 0730 and 1600 (CST), Monday through Friday. *(NOTE: Do not use the suggestion program to submit changes or corrections for this course.)*

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to A Successful Course, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If this person can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 18 hours (6 points).

Material in this volume is technically accurate, adequate, and current as of March 1980.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of student-centered objectives. Each of these carries a three-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see whether your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Career Field Duties and Responsibilities

COMMUNICATIONS systems are changing. To speed communications and at the same time improve reliability, more and more electronic gear is being incorporated into the telephone systems. Now the telephone has a new look with transistorized circuit components and pushbutton dial. As a result, the telephone equipment installation and repair specialist must be knowledgeable and well trained. This course presents knowledge for you to study during the on-the-job training program.

Since this chapter is an introduction to career field duties and responsibilities, we will discuss some of the details of the career field. This will include the specialty descriptions, duties, responsibilities, and career progression for the telephone equipment installation and repair specialist. The Specialty Training Standard (STS) and its relation to on-the-job training will also be discussed.

1-1. The Wire Communications Systems Maintenance Career Field (36)

The airman Wire Communications Systems Maintenance Career Field is functional because the jobs require common knowledge and related skills. For example, to do the work in each specialty, the specialist must have training in electronics and must be able to install and/or repair communications systems equipment.

001. Use figure 1-1 to match AFSCs and career field functions.

Figure 1-1 shows that the scope of the Wire Communications Systems Maintenance Career Field is very broad. It shows two manager and superintendent blocks and under them are six career ladders. As you can see, this 36 career field includes Air Force personnel who do telephone outside plant installation and maintenance and Air Force people who do telephone inside plant service. The tasks for each ladder are comparable in that they require a knowledge of AC and DC electricity, and a knowledge of and skill in tracing and analyzing circuits, planning and doing installation procedures, using test equipment to locate electronic equipment troubles, and repairing and replacing electronic units and/or devices.

This illustrated career field organizational structure is typical of the functional groupings for Air Force specialties. It is functional because the ladders in each managerial group are similar in their training requirements and in the skill needed to do the field tasks. Thus, you may work in close coordination with airmen who specialize in other duties. For example, you may work with a specialist testing cable whose AFSC is 36151. The 36150 specialist is responsible for maintenance of outside telephone wire and antennas. The 36151 specialist also splices missile communications system cable. The 36251 specialist repairs telephone switching equipment, and the 36252 specialist services electronic switching systems equipment. This figure shows also that the 36253 specialist is responsible for missile control communications systems.

At this point, we are interested only in the telephone equipment installation ladder (AFSCs 36234/54/74, as shown in the first column on the right, fig. 1-1). Your specific ladder identifies only telephone equipment, but you learned in the resident course that key systems and 302 and AN/GTC–28 communications equipment maintenance are also included as your duty.

By reading the legend for figure 1-1 and comparing its information to the 362X4 ladder, you can see that a basic course is desirable in the telephone equipment installation and repair specialist ladder. Having completed the course, the airman will use a CDC and on-the-job training to gain knowledge and experience in order to progress up the ladder toward the telephone plant maintenance superintendent.

Exercise (001):

Match each function in column A with the most appropriate AFSC listed in column B.

Column A	*Column B*
____ (1) Telephone switching equipment maintenance.	a. 36170.
____ (2) Telephone installation and repair.	b. 36131.
____ (3) Antenna maintenance.	c. 36271.
____ (4) Missile control communications system maintenance.	d. 36232.
____ (5) Electronic switching systems maintenance.	e. 36273.
	f. 36254.

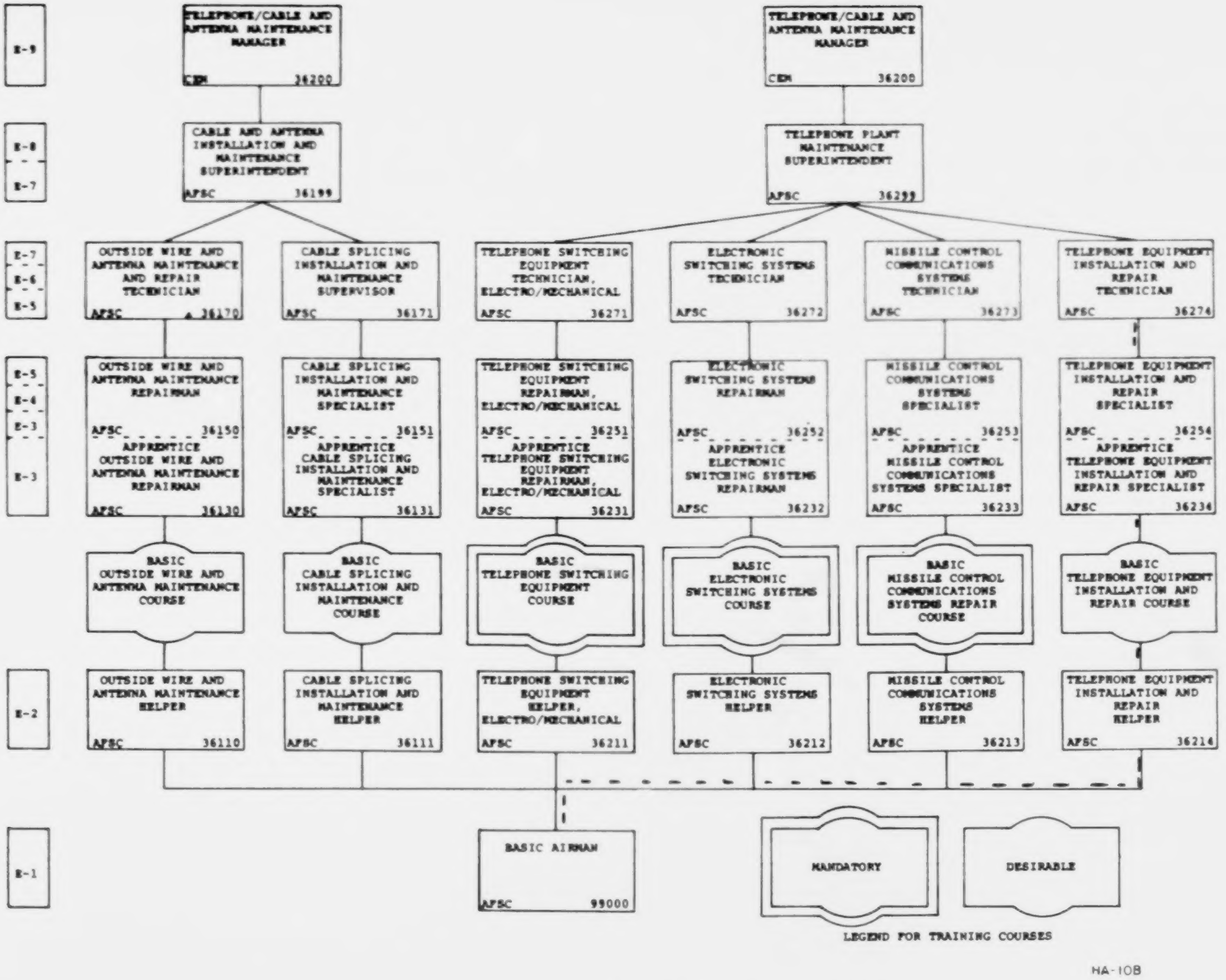
E-9
TELEPHONE/CABLE AND ANTENNA MAINTENANCE MANAGER
CEM 36200
TELEPHONE/CABLE AND ANTENNA MAINTENANCE MANAGER
CEM 36200
E-8
E-7
CABLE AND ANTENNA INSTALLATION AND MAINTENANCE SUPERINTENDENT
AFSC 36199
TELEPHONE PLANT MAINTENANCE SUPERINTENDENT
AFSC 36299
E-7
E-6
E-5
OUTSIDE WIRE AND ANTENNA MAINTENANCE AND REPAIR TECHNICIAN
AFSC 36170
CABLE SPLICING INSTALLATION AND MAINTENANCE SUPERVISOR
AFSC 36171
TELEPHONE SWITCHING EQUIPMENT TECHNICIAN, ELECTRO/MECHANICAL
AFSC 36271
ELECTRONIC SWITCHING SYSTEMS TECHNICIAN
AFSC 36272
MISSILE CONTROL COMMUNICATIONS SYSTEMS TECHNICIAN
AFSC 36273
TELEPHONE EQUIPMENT INSTALLATION AND REPAIR TECHNICIAN
AFSC 36274
E-5
E-4
E-3
E-3
OUTSIDE WIRE AND ANTENNA MAINTENANCE REPAIRMAN
AFSC 36150
APPRENTICE OUTSIDE WIRE AND ANTENNA MAINTENANCE REPAIRMAN
AFSC 36130
CABLE SPLICING INSTALLATION AND MAINTENANCE SPECIALIST
AFSC 36151
APPRENTICE CABLE SPLICING INSTALLATION AND MAINTENANCE SPECIALIST
AFSC 36131
TELEPHONE SWITCHING EQUIPMENT REPAIRMAN, ELECTRO/MECHANICAL
AFSC 36251
APPRENTICE TELEPHONE SWITCHING EQUIPMENT REPAIRMAN, ELECTRO/MECHANICAL
AFSC 36231
ELECTRONIC SWITCHING SYSTEMS REPAIRMAN
AFSC 36252
APPRENTICE ELECTRONIC SWITCHING SYSTEMS REPAIRMAN
AFSC 36232
MISSILE CONTROL COMMUNICATIONS SYSTEMS SPECIALIST
AFSC 36253
APPRENTICE MISSILE CONTROL COMMUNICATIONS SYSTEMS SPECIALIST
AFSC 36233
TELEPHONE EQUIPMENT INSTALLATION AND REPAIR SPECIALIST
AFSC 36254
APPRENTICE TELEPHONE EQUIPMENT INSTALLATION AND REPAIR SPECIALIST
AFSC 36234
BASIC OUTSIDE WIRE AND ANTENNA MAINTENANCE COURSE
BASIC CABLE SPLICING INSTALLATION AND MAINTENANCE COURSE
BASIC TELEPHONE SWITCHING EQUIPMENT COURSE
BASIC ELECTRONIC SWITCHING SYSTEMS COURSE
BASIC MISSILE CONTROL COMMUNICATIONS SYSTEMS REPAIR COURSE
BASIC TELEPHONE EQUIPMENT INSTALLATION AND REPAIR COURSE
E-2
OUTSIDE WIRE AND ANTENNA MAINTENANCE HELPER
AFSC 36110
CABLE SPLICING INSTALLATION AND MAINTENANCE HELPER
AFSC 36111
TELEPHONE SWITCHING EQUIPMENT HELPER, ELECTRO/MECHANICAL
AFSC 36211
ELECTRONIC SWITCHING SYSTEMS HELPER
AFSC 36212
MISSILE CONTROL COMMUNICATIONS SYSTEMS HELPER
AFSC 36213
TELEPHONE EQUIPMENT INSTALLATION AND REPAIR HELPER
AFSC 36214
E-1
BASIC AIRMAN
AFSC 99000
MANDATORY
DESIRABLE
LEGEND FOR TRAINING COURSES
HA-108

Figure 1–1. Airman Wire Communications Systems Maintenance Career Field Chart.

1-2. Career Field Specialty Descriptions

What will be expected of you as a telephone equipment installation and repair specialist? AFR 39–1, *Airman Classification Regulation*, lists the duties and responsibilities for people in the various career fields. For the telephone equipment installation and repair specialist area, there are two lists (specialty descriptions): one for the 3- and 5-level AFSCs and one for the 7-level AFSC.

002. Cite duties and responsibilities of people in the Telephone Equipment Installation and Repair Career Field.

5-Level Duties and Responsibilities. Figure 1-2 shows that with a 36254 AFSC you may be responsible for telephone subsets, key telephone systems, key switch systems, and associated equipment. You may also be required to climb poles, connect protectors, run wire, install telephones, and install and maintain key system cable, racks, and KTUs.

Although the description doesn't specify the test equipment that you will use, it does state that you will use such equipment for locating faulty telephone equipment. As a specialist, you should understand the principles of operation of both the test equipment and the assigned telephone equipment.

7-Level Duties and Responsibilities. The duties and responsibilities for a technician with a 36274 AFSC are much more involved, as you can see from the partial specialty description shown in figure 1-3. Some of these duties are studying key systems to determine required KTU strappings so that the desired features are provided, identifying the operating procedures to be used in accomplishing jobs, and establishing performance standards for the team(s) and the controls to insure that they are adhered to. This technician also sets priorities for jobs, supervises the personnel, and inspects the completed job. The technician's conduct and performance often determine the efficiency of the organization.

As you can see, telephone equipment installation and repair specialists and technicians must know many things. A course such as this cannot cover all phases in detail. Experience in the field will certainly improve your skill and increase your store of information; and where available, additional Air Force reference material (electrical and electronic technical publications) will fill in the blank spots and broaden your background. Remember that the manner in which you perform is indicative of your ability, your attitude, or both. Neglectful or slovenly work usually results in communications systems breakdowns. You are responsible to your maintenance section, to your base commander, to the Air Force, and to your country for a reliable communications network.

Exercises (002):

1. List telephone equipment that 3- and 5-level telephone equipment installation and repair specialists will install and repair.

2. List some subset components which you may replace.

3. Name two key system units that you may replace.

4. Cite supervisory duties which a 5-level telephone equipment installation and repair specialist may perform.

5. State two ways that technicians help telephone equipment installation and repair specialists perform their tasks.

1-3. Specialty Training Standard

Now that you have seen the many duties and responsibilities for the 3, 5, and 7 levels of your AFS, consider the document which lists AFS task knowledges and skill levels—the Specialty Training Standard.

003. Using figures 1-4 and 1-5 as needed, identify applicable proficiency levels for listed career field tasks and correlate tasks with job references.

The Specialty Training Standard is an Air Force training control document. It identifies the tasks of your career field and the skill level that you are expected to reach as you advance toward the superintendent category. We know, though, that it is not possible to attain a skill without developing knowledge at the same time. In an effort to show both the eventual skill level and the prospective knowledge development associated with each task, headquarters personnel established a coding pattern.

Tasks. One page of the STS for your career field is shown as figure 1-4. According to it, you will make wire runs and install telephones. You also will install and maintain 1A1, key telephone systems. Your tasks involve understanding the theory of the key system operation and the capabilities of KTUs to meet specific requirements. They also require you to perform operational tests and correctional maintenance. In column 2A to the right of the installation task, you can see the code 2b indicated for the 3-skill-level specialist.

Skill-Level Codes. The meaning of this code is found in the proficiency code key shown in figure 1-5. The capital letters in the Scale Value column identify subject knowledge levels, the lowercase letters identify task knowledge levels, and the numbers pertain to task performance (skill) levels. While you are studying figure 1-5, note that each of these codings (numbers and letters) has a specific meaning or definition. For example, a scale value coding of "4" means that the individual can do the complete task quickly and accurately. He or she can tell or show others how to do the task (HIGHLY PROFICIENT). A coding of "a" means that the trainee can name parts, tools, and simple facts about the task (NOMENCLATURE). A coding of "B" means that the

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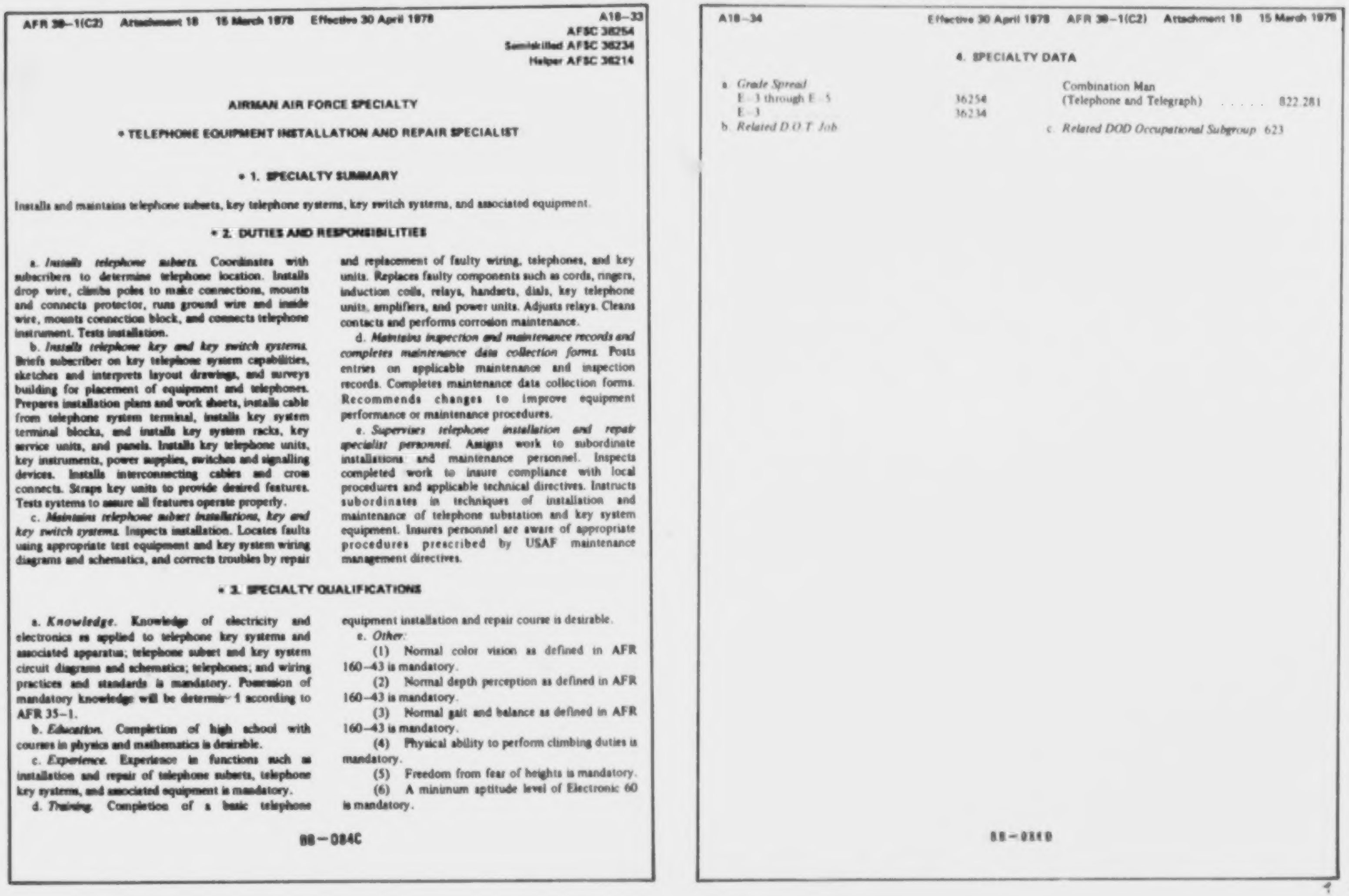


AFR 39–1(C2) Attachment 18 15 March 1978 Effective 30 April 1978 A18–33

AFSC 36254
Semiskilled AFSC 36234
Helper AFSC 36214

AIRMAN AIR FORCE SPECIALTY

* TELEPHONE EQUIPMENT INSTALLATION AND REPAIR SPECIALIST

* 1. SPECIALTY SUMMARY

Installs and maintains telephone subsets, key telephone systems, key switch systems, and associated equipment.

* 2. DUTIES AND RESPONSIBILITIES

a. *Installs telephone subsets.* Coordinates with subscribers to determine telephone location. Installs drop wire, climbs poles to make connections, mounts and connects protector, runs ground wire and inside wire, mounts connection block, and connects telephone instrument. Tests installation.

b. *Installs telephone key and key switch systems.* Briefs subscriber on key telephone system capabilities, sketches and interprets layout drawings, and surveys building for placement of equipment and telephones. Prepares installation plans and work sheets, installs cable from telephone system terminal, installs key system terminal blocks, and installs key system racks, key service units, and panels. Installs key telephone units, key instruments, power supplies, switches and signalling devices. Installs interconnecting cables and cross connects. Straps key units to provide desired features. Tests systems to assure all features operate properly.

c. *Maintains telephone subset installations, key and key switch systems.* Inspects installation. Locates faults using appropriate test equipment and key system wiring diagrams and schematics, and corrects troubles by repair and replacement of faulty wiring, telephones, and key units. Replaces faulty components such as cords, ringers, induction coils, relays, handsets, dials, key telephone units, amplifiers, and power units. Adjusts relays. Cleans contacts and performs corrosion maintenance.

d. *Maintains inspection and maintenance records and completes maintenance data collection forms.* Posts entries on applicable maintenance and inspection records. Completes maintenance data collection forms. Recommends changes to improve equipment performance or maintenance procedures.

e. *Supervises telephone installation and repair specialist personnel.* Assigns work to subordinate installations and maintenance personnel. Inspects completed work to insure compliance with local procedures and applicable technical directives. Instructs subordinates in techniques of installation and maintenance of telephone substation and key system equipment. Insures personnel are aware of appropriate procedures prescribed by USAF maintenance management directives.

* 3. SPECIALTY QUALIFICATIONS

a. *Knowledge.* Knowledge of electricity and electronics as applied to telephone key systems and associated apparatus; telephone subset and key system circuit diagrams and schematics; telephones; and wiring practices and standards is mandatory. Possession of mandatory knowledge will be determined according to AFR 35–1.

b. *Education.* Completion of high school with courses in physics and mathematics is desirable.

c. *Experience.* Experience in functions such as installation and repair of telephone subsets, telephone key systems, and associated equipment is mandatory.

d. *Training.* Completion of a basic telephone equipment installation and repair course is desirable.

e. *Other:*

(1) Normal color vision as defined in AFR 160–43 is mandatory.

(2) Normal depth perception as defined in AFR 160–43 is mandatory.

(3) Normal gait and balance as defined in AFR 160–43 is mandatory.

(4) Physical ability to perform climbing duties is mandatory.

(5) Freedom from fear of heights is mandatory.

(6) A minimum aptitude level of Electronic 60 is mandatory.

88–084C

A18–34 Effective 30 April 1978 AFR 39–1(C2) Attachment 18 15 March 1978

4. SPECIALTY DATA

a. *Grade Spread*

E–3 through E–5	36254
E–3	36234

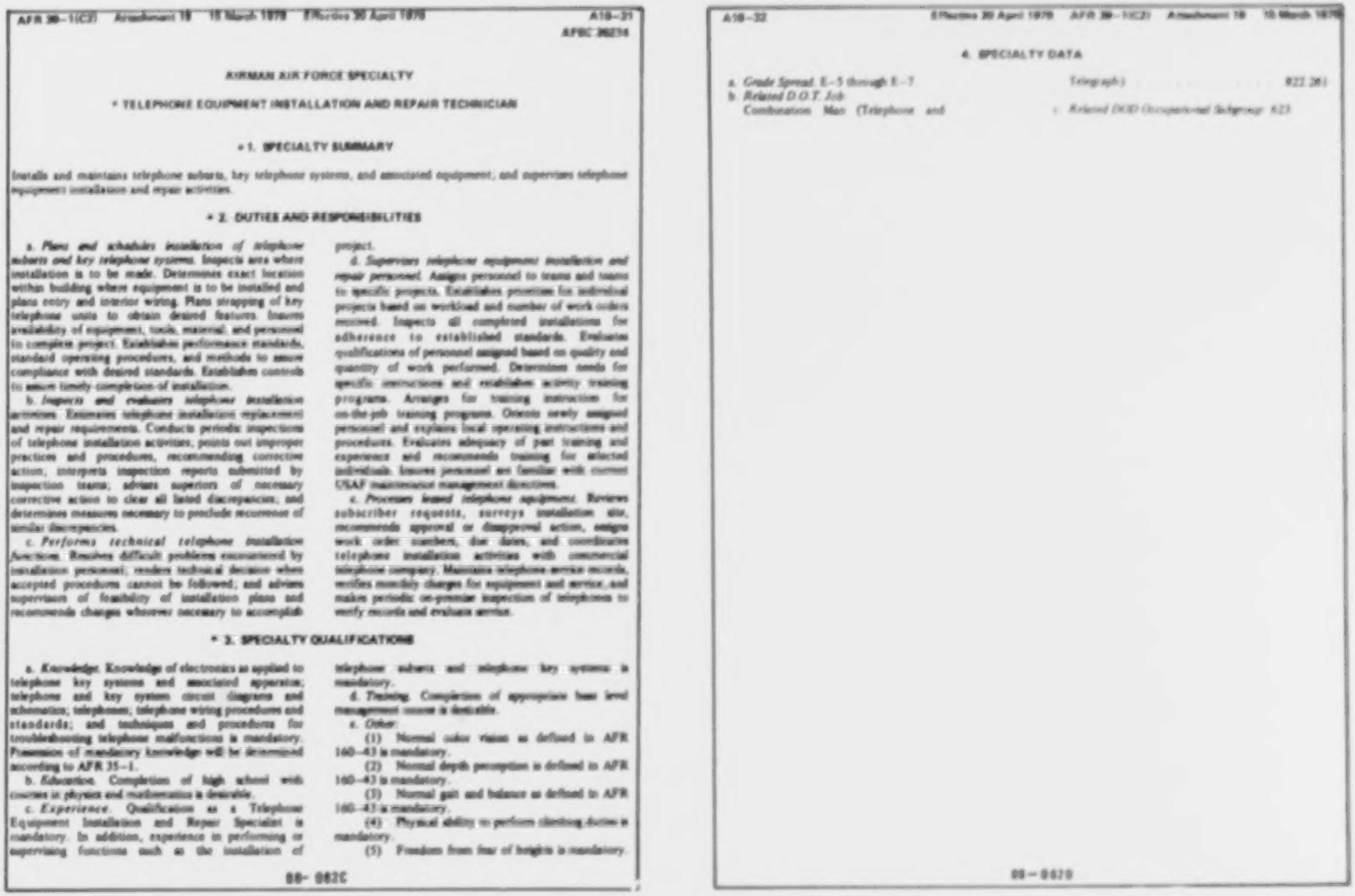
b. *Related D.O.T. Job*

Combination Man (Telephone and Telegraph) 822.281

c. *Related DOD Occupational Subgroup* 623

88–084D

Figure 1–2. Sample Air Force specialist specialty description.



AFR 39-1(C2) Attachment 18 15 March 1978 Effective 30 April 1978 A18-31

AFSC 36274

AIRMAN AIR FORCE SPECIALTY

★ TELEPHONE EQUIPMENT INSTALLATION AND REPAIR TECHNICIAN

★1. SPECIALTY SUMMARY

Installs and maintains telephone subsets, key telephone systems, and associated equipment; and supervises telephone equipment installation and repair activities.

★2. DUTIES AND RESPONSIBILITIES

a. *Plans and schedules installation of telephone subsets and key telephone systems.* Inspects area where installation is to be made. Determines exact location within building where equipment is to be installed and plans entry and interior wiring. Plans strapping of key telephone units to obtain desired features. Insures availability of equipment, tools, material, and personnel to complete project. Establishes performance standards, standard operating procedures, and methods to assure compliance with desired standards. Establishes controls to assure timely completion of installation.

b. *Inspects and evaluates telephone installation activities.* Estimates telephone installation replacement and repair requirements. Conducts periodic inspections of telephone installation activities; points out improper practices and procedures, recommending corrective action; interprets inspection reports submitted by inspection teams; advises superiors of necessary corrective action to clear all listed discrepancies; and determines measures necessary to preclude recurrence of similar discrepancies.

c. *Performs technical telephone installation functions.* Resolves difficult problems encountered by installation personnel; renders technical decision when accepted procedures cannot be followed; and advises supervisors of feasibility of installation plans and recommends changes wherever necessary to accomplish project.

d. *Supervises telephone equipment installation and repair personnel.* Assigns personnel to teams and teams to specific projects. Establishes priorities for individual projects based on workload and number of work orders received. Inspects all completed installations for adherence to established standards. Evaluates qualifications of personnel assigned based on quality and quantity of work performed. Determines needs for specific instructions and establishes activity training programs. Arranges for training instruction for on-the-job training programs. Orients newly assigned personnel and explains local operating instructions and procedures. Evaluates adequacy of past training and experience and recommends training for selected individuals. Insures personnel are familiar with current USAF maintenance management directives.

e. *Processes leased telephone equipment.* Reviews subscriber requests, surveys installation site, recommends approval or disapproval action, assigns work order numbers, due dates, and coordinates telephone installation activities with commercial telephone company. Maintains telephone service records, verifies monthly charges for equipment and service, and makes periodic on-premise inspection of telephones to verify records and evaluate service.

★3. SPECIALTY QUALIFICATIONS

a. *Knowledge.* Knowledge of electronics as applied to telephone key systems and associated apparatus; telephone and key system circuit diagrams and schematics; telephones; telephone wiring procedures and standards; and techniques and procedures for troubleshooting telephone malfunctions is mandatory. Possession of mandatory knowledge will be determined according to AFR 35-1.

b. *Education.* Completion of high school with courses in physics and mathematics is desirable.

c. *Experience.* Qualification as a Telephone Equipment Installation and Repair Specialist is mandatory. In addition, experience in performing or supervising functions such as the installation of telephone subsets and telephone key systems is mandatory.

d. *Training.* Completion of appropriate base level management course is desirable.

e. *Other:*

(1) Normal color vision as defined in AFR 160-43 is mandatory.

(2) Normal depth perception as defined in AFR 160-43 is mandatory.

(3) Normal gait and balance as defined in AFR 160-43 is mandatory.

(4) Physical ability to perform climbing duties is mandatory.

(5) Freedom from fear of heights is mandatory.

88-082C

A18-32 Effective 30 April 1978 AFR 39-1(C2) Attachment 18 15 March 1978

4. SPECIALTY DATA

a. *Grade Spread.* E-5 through E-7

b. *Related D.O.T. Job*

Combination Man (Telephone and Telegraph) 822.381

c. *Related DOD Occupational Subgroup:* 623

88-0820

Figure 1-3. Sample Air Force technician specialty description.

1. TASKS, KNOWLEDGE AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 SKILL LEVEL			3. 5 SKILL LEVEL			4. 7 SKILL LEVEL		
	A AFSC Crs	B Date OJT Started	C Date Compld & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Compld & Trainee's Supervisor's Initials	A AFSC Crs	B Date OJT Started	C Date Compld & Trainee's Supervisor's Initials
7c. Process and control materiel	2b/-			2b			3c		V1C3
SR: AFM 66-1 (vol X, chap 3); TO 00-20-3									
d. Accomplish key telephone system records/ worksheets	2b			3c			3d		V1C3
SR: TO 00-20-8									
8. ELECTRONIC FUNDAMENTALS									
SR: TO 31-1-141 Series									
a. Principles applicable to tasks listed in this STS	B			B			B		V1C4, C5
9. TOOLS AND TEST EQUIPMENT									
SR: TOs 32-1-101, 31W1-2GT-271									
a. Use and care for handtools	2b			4c			4d		V1C2 V2C4
b. Use test equipment in performing installation and maintenance	2b			3c			3d		V3C2 V3C6
10. TELEPHONE SUBSTATION INSTALLATION									
SR: AFM 100-22; TOs 31W-1-16, 31W-3-6, 31W1-102, 31W2-4-172, 31W2-4-183-2, 31W3-10-20									
a. Fundamentals of telephony	B			B			C	NO ADVANCED COURSE	V1C6; V2C1, C2
b. Install external wire from terminal to building	2b			3c			4c		V3C2, C3
c. Make inside wire/cable run	2b			3c			4c		V3C3
d. Install/connect telephone instruments	2b			3c			4c		V3C3, C5
e. Perform operational test	2b			3c			4c		V3C4
f. Perform corrective maintenance	2b			3c			4c		V3C5
g. Prevention and treatment of corrosion	B			B			C		V3C5
SR: TO 1-1-2									
11. 1A1 KEY TELEPHONE SYSTEM INSTALLATION AND MAINTENANCE									
SR: TOs 31W2-10-15									
a. Theory of system operation	B			C			D		V4C2
b. Capabilities of KTUs/Power supplies	B			C			D		V4C3
c. Select telephones to meet specific requirements	2b			3c			4c		V4C1
d. Install 1A1 type key system	2b			3c			4c		V4C3
e. Perform operational test	2b			3c			4c		V4C4
f. Perform corrective maintenance	2b			3c			4c		V4C9

Figure 1-4. Partial STS task listing for 362X4 career field.

THIS BLOCK IS FOR IDENTIFICATION PURPOSES ONLY

TRAINEE

NAME (*Last, First, Middle Initial*)	INITIALS (*In writing*)	SSAN

IMMEDIATE SUPERVISOR'S NAME AND INITIALS (*In writing*)

N/I	N/I
N/I	N/I
N/I	N/I
N/I	N/I
N/I	N/I
N/I	N/I

QUALITATIVE REQUIREMENTS

PROFICIENCY CODE KEY

	SCALE VALUE	DEFINITION: The Individual
TASK PERFORMANCE LEVELS	1	Can do simple parts of the task. Needs to be told or shown how to do most of the task. (EXTREMELY LIMITED)
	2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy. (PARTIALLY PROFICIENT)
	3	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy. (COMPETENT)
	4	Can do the complete task quickly and accurately. Can tell or show others how to do the task. (HIGHLY PROFICIENT)
* TASK KNOWLEDGE LEVELS	a	Can name parts, tools, and simple facts about the task. (NOMENCLATURE)
	b	Can determine step by step procedures for doing the task. (PROCEDURES)
	c	Can explain why and when the task must be done and why each step is needed. (OPERATING PRINCIPLES)
	d	Can predict, identify, and resolve problems about the task. (ADVANCED THEORY)
** SUBJECT KNOWLEDGE LEVELS	A	Can identify basic facts and terms about the subject. (FACTS)
	B	Can explain relationship of basic facts and state general principles about the subject. (PRINCIPLES)
	C	Can analyze facts and principles and draw conclusions about the subject. (ANALYSIS)
	D	Can evaluate conditions and make proper decisions about the subject. (EVALUATION)

EXPLANATIONS

* — A task knowledge scale value may be used alone or with a task performance scale value to define a level of knowledge for a specific task. (Examples: b and 1b)

** — A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a subject common to several tasks.

— — This mark is used alone instead of a scale value to show that no proficiency training is provided in the course, or that no proviciency is required at this skill level.

X — This mark is used alone in course columns to show that training is not given due to limitations in resources.

Figure 1-5. Proficiency code key for STS.

individual can explain the relation of basic facts and state general principles about the subject (PRINCIPLES).

To further consider the STS codes, look again at task 11d, in figure 1-4, install 1A1 type key system. Note that the 3-level column is coded 2b, the 5-level column is coded 3c, and the 7-level column is coded 4c. Checking the numerical codings for this task against the code key of figure 1-5 reveals that the 3-level worker is expected to be partially proficient, whereas the 5- and 7-level people are expected to be competent and highly proficient. The letter codings for this task show that you must show progress. To illustrate, the 3-level worker can determine step-by-step procedures for doing this task, the 5-level specialist can explain why and when the task must be done and why each step is needed, and the 7-level technician can complete the task quickly and accurately and can tell or show others how to do the task. Thus, the 7-level technician understands the complete theory of the task.

Although career field knowledge can be gained from studying the CDC, a full grasp of it comes from working on the job. A quick look at several other entries in the STS will show that, in most cases, your task proficiency and skill level rise together. As a 5-level installer-specialist, you will be expected to be more proficient in both task knowledge and performance than a 3-level worker. In turn, the technician must have greater knowledge and skill than the 5-level specialists.

Study References. By scanning the contents of this course, you will find that the chapters describe knowledge elements listed in the STS. Furthermore, on this example page of the STS, the CDC volume and chapter for each item are identified in the right-hand column. For example, STS task 10e has a V3, C4 identification. From this listing, we learn that Chapter 4 of Volume 3 describes operational testing of a telephone station. In addition, the STS shows task 11e with a V4, C4 identification. Thus, Chapter 4 of Volume 4 describes operational testing of the 1A1 key telephone system.

Additional study references are also shown in the STS. Following each major heading is a list of references that, when researched, will provide thorough coverage of the subject. Accordingly, the technical order references that provide information on telephone substation installation are listed as SR under item 10 on the STS.

Exercises (003):

1. Use figure 1-4 and give the 5-skill-level proficiency requirement for task 11f.

2. What does the proficiency code 3c mean with respect to knowledge and performance?

3. Cite the proficiency code for the 7 skill level for task 10e.

4. Using the sample STS page, where in this course will you find information about corrective maintenance for the key systems?

5. Using the sample STS page, identify the chapter and volume in this course that describes the capabilities of KTUs.

6. Using figure 1-4, identify a technical order reference for installing 1A1 key telephone system equipment.

1-4. Prerequisite Qualifications for Progression in a Career Field

In the preceding sections, we mentioned the requirements for upgrading airmen. AFR 50-23, *On-the-Job Training*, has more complete details about the procedures. We will briefly review some of the steps so that you will be more familiar with some of the requirements for job progression.

004. Cite steps and procedures by which an airman progresses in his or her career field.

Job Progression. While we are thinking of progression in the career field, let's consider figure 1-1 in more detail and see what it reveals. In the vertical column at the left side of the chart, you can see how the grade levels (E-1 thru E-9) apply to the various AFSCs. For example, you can advance to grade E-3 while holding a 36234 AFSC, to grades E-4 and E-5 while holding a 36254 AFSC, and to grades E-6 and E-7 while holding a 36274 AFSC.

Job Knowledge Training. When you have received your 3-level skill rating, you are required to study this CDC because it is one part of the dual-channel concept of on-the-job training. The dual-channel concept of on-the-job training is the program that permits you to gain career knowledge while you perform on the job. Self-study is a basic principle of the OJT concept. Of course, your organization can provide you help if it is needed.

You are encouraged to study each chapter and to do the learning objective exercises for it before starting the next chapter. Compare your answers to the exercise answers provided in the back of the volume. When you have finished the study of the volume, do the Volume Review Exercise (VRE). This exercise is usually completed while you are supervised, but it is an "open book" exercise. Hence, you are authorized to use the text to answer the exercise items. The Extension Course Institute (ECI) grades your answer sheet and returns the results to you. Study these results to see whether or not there is an area where you are weak. If you have done poorly on any section, restudy it before taking the Course Examination (CE). You take the CE after completing all volumes of the course. It is a closed book test. ECI awards a certificate when you satisfactorily complete a CE. You have 12 months to finish the volumes, the VRE, and the CE. The Course Examination may be retaken only once.

Job Proficiency Training. The second channel of OJT uses the learn-by-doing concept. Job proficiency training is normally conducted by the organization to which you are assigned. It should be evident that job proficiency relates to the practical work—the skill that you have when doing tasks. When you have done the simple tasks skillfully, you are assigned more complex tasks. Development of your proficiency or skill comes from continuing practice of the specific tasks included in your job. In this manner, you will learn all the elements of the job. Remember, while progressing, you gain knowledge as well as skill.

Your immediate supervisor should have an STS and/or Job Proficiency Guide (JPG) for evaluating you and recording your task accomplishments. The STS includes tasks for equipment which may not be at your duty station. For instance, you may be maintaining 302 switch units; yet, the STS also shows that you're responsible for subset installation and maintenance and for key systems. Your supervisor certifies the completion of each task by placing the date you reached that proficiency opposite the task and by initialing beside the date. If an STS is not available or if it is not broken down adequately for the supervisor to show that the trainee is doing the entire job, the supervisor will use a JPG which identifies tasks and references for these tasks. For example, the JPG could have corrosion control procedures listed and show TO 1–1–2 as a reference for this heading. The JPG also shows the proficiency level you must reach before the supervisor certifies that you are qualified to do this task. Supervisor certification is a prerequisite for airman upgrade.

The supervisor can recommend you for upgrading when you have the certificate from ECI for having completed the CDC and when you have been certified as being proficient. After you have progressed to the 5 level and have been awarded AFSC 36254, you must work toward the 36274 AFS. Working toward the 7-level AFS should include the research of management publications, a study of CDC 36274, and additional experience in maintenance of telephone communications equipment. Remember, use the available technical orders while doing this maintenance.

Job Promotion. We have mentioned in the first section of this objective that grade levels relate to the skill level. We also noted there that the requirements for skill-level upgrading are described in AFR 50–23. We are not detailing here the requirements for advancement in grade levels, because AFR 39–29, *Promotion of Airmen*, provides this information. However, we are briefly listing them. Passing a Skill Knowledge Test (SKT) and passing a Promotion Fitness Examination (PFE) are two factors in the Weighted Airman Promotion System (WAPS) used for promoting an airman to E–5 through E–7. AFM 35–8, *Air Force Military Personnel Testing System*, describes the PFE as a test which measures the airman's knowledge for solving noncommissioned officer problems that relate to general military areas. The SKT measures the airman's knowledge of his or her career field as indicated by the STS. The job-type problems which are developed for the SKT are referenced to the CDC.

Reliable maintenance of communications equipment is the result of effective application of job related knowledges to the particular jobs to which you have been assigned. It is important, then, that you study conscientiously to learn the principles of your job and work patiently and with accuracy to provide the quality work which identifies a maintenance organization as efficient.

Exercises (004):

1. What grades can an airman have who has the AFSC 36254?

2. Can you make E–8 while having a 36274 AFSC?

3. List three ways in which you demonstrate your knowledge of the CDC materials.

4. State two ways by which you gain knowledge about your job.

5. How does the JPG differ from the STS?

6. What must an airman do to show that she or he is qualified for advancement in a career field ladder?

7. Give the third requirement for upgrade consideration after having completed the CDC and having been certified as qualified.

8. List the two E–6 promotion factors listed in this chapter.

9. What reference(s) is used when developing the 36254 SKT?

10. List some of the things that you can do that will result in efficient operation of the telephone systems equipment.

CHAPTER 2

Introduction to Supervision and Management

LIGHTING A CIGAR with a $50 bill is not an example of good financial management. Using the 3-volt selection of a multimeter while testing for voltage in a 48-volt circuit, though not as impressive, is likewise an example of poor management. It could also be evidence of improper supervision.

AFM 25-1, *USAF Management Process,* lists the functions of management as controlling, directing, planning, organizing, and coordinating. The degree of management responsibility, of course, increases with rank. Through the efforts of workers, management gets the desired results.

Supervision has often been considered synonymous with management because both are defined with the words controlling, directing, commanding, guiding, etc. For our purpose in this chapter, we are considering management as the function that specifies the procedures for doing the jobs and that checks to insure that they are met. Thus, it is the command authority. Supervision is an element of that function. The supervisor leads, encourages, guides, advises, etc., to provide the desired results for management. This chapter describes both functions briefly and relates your career field position to Air Force management.

2-1. Management

Good management makes policies which provide maximum use of Air Force resources with the most efficiency and at the lowest cost. Management is responsible for manpower, materiel, and financial resources. These policies control the people while working to achieve the organizational objectives. Continued confidence in the Air Force will result only when management has demonstrated effective control and maximum economy to achieve its mission.

005. State the responsibilities of management and specify the methods management uses to meet these responsibilities.

Basic Management Functions. You should recognize that some management functions are common or basic to all managers. Then there are some functions that are special to the individual manager. We will look first at those that are basic.

Management makes decisions. As part of management, you must identify prevailing and future problems and make the decisions which will provide a solution. To know how to reach the solution, you must understand the overall organizational operation and the relationship of each section for the entire operation. Further, you must know the specific work procedures for the system, the people on whom you depend, and methods for counseling and disciplining people. You must also see that the solution is used in the prescribed manner.

Management plans. Management plans programs. Thus, you determine the goals to be reached, what is required to reach these goals, how much is needed, and the time that it is needed. You also schedule the work and assign the people to produce these goals. Plan the evaluation of your program so that the skill of a worker is observed, the accuracy of the methods used is noted, and the suitability of these methods is determined.

Management organizes. Management organizes the workers who use the resources. Resources include money and materiel. Good organization consists of selecting a course of action and arranging the functions into a practical system for completing the selected course. Management assembles the resour allocates them to the proper functions, and authorizes the functions to use them. Also, you'll group organizations according to their interrelationship and function. For example, cable installation, telephone repair, and telephone switching system maintenance are a logical grouping; whereas, telephone repair, aircraft service, and vehicle maintenance are not functionally related.

Management directs. As a manager, you provide for efficient operation by organizing the workers and directing the use of resources. In addition to the listed resources (money and materiel), you'll also be concerned with time, such as worktime, reporting time, leave time, and overtime (exception time). (REMEMBER: Materiel for which you may be responsible includes tools, telephone sets, key system equipment, test equipment, wire, military vehicles, tables, chairs, workbenches, etc.) Directing, then, consists of supervising people and developing procedures for the people using the equipment. Giving thought to these two responsibilities, we recognize that management cannot treat people in the same way that they direct the operation of equipment. We know that people are able to think; thus, they can start, control, and complete operations (equipment and organizational). Further, they are sensitive to management attitudes. If you expect people to work willingly and use the resources accurately, you must motivate them. When a worker deserves an award for outstanding performance, see that he or she gets it. Secondly, you respect the workers and show confidence in them by giving them authority when assigning responsibilities.

Management coordinates. Managers must coordinate with each other if they are to achieve their common goals. Coordination is important because all Air Force units are working together to accomplish the Air Force mission; hence, no unit can function in isolation. Coordination is also needed between management and the subordinate functiona so that they have unity in their efforts. In this manner, the functions get the right people at the right time so that they can do the right things.

Your work as a manager may not be as noticeable as the efforts of your workers, since your duties include knowing the purpose for the work and coordinating the activities of the sections to provide the desired results; whereas, the workers use the tools, install the equipment, repair or replace the components, and use and prepare the records which are observable.

Management evaluates data. An end result of operations is data. This data is information about what happened. Management evaluates this information to estimate future requirements and determine operational standards.

We have seen that management has resources and a mission and that people use the resources to reach the management's objectives. You should not be a part of management's problem but should contribute to Air Force management by doing quality work. This good work may soon reward you with a supervisory role in Air Force management.

Exercises (005):

1. List some management responsibilities.

2. List some telephone management methods for controlling the organization.

3. Give resources that telephone management controls.

4. List some needs of the workers.

5. Compare management and worker duties.

006. List special management functions for communications managers and cite typical management tasks.

Management Functions Special to Communications Managers. The communications manager will plan base communications facilities and the services they require. Hence, a manager will follow or make policies for getting communications equipment and for installing, operating, and maintaining it. You may be responsible for leased and Government-owned communications systems. You may correlate telephone charges and credits to insure that all are accurate and authorized. In case of a discrepancy, you may then assist the communications officer in negotiating to correct the billing statement.

Typical tasks include developing a base wire communications plan for system modification or expansions; assigning the classification to base telephones; verifying equipment status and use; ordering supplies and verifying its availability; programming new and replacement systems or components, plus overseeing the replacement and repair service; keeping current with regulation policies and assuring compliance with them; and preparing programs for educating customers on the available service, and the expected service quality and its limitations.

Communications management must be centralized because of the many installed systems (leased, Government-owned dial and key telephone, radio, teletypewriter, data processing, security, etc.), because of the increasing number of electronic systems, and because tariff rates vary and change often. Centralization permits the Air Force to provide reliable service at the lowest possible cost.

The manager often has to be resolute in denying customers more service when, according to the established policy, they have adequate service, although they think their requests are fully justified. Yet, you must also be moderate in your actions and words if you are to be effective as a negotiator with Government and commercial supervisors during consultations about controversial charges and changes, quality of service limitations, service maintenance responsibilities, or failure to perform services, etc. There are many other difficult tasks for a manager, but we won't discuss most of them because you will see them in detail in the 7-level CDC. Typical tasks are: preparing duty schedules, planning and assigning training and evaluations, and writing performance reports.

Exercises (006):

1. List three basic functions that a communications manager will do.

2. What should a manager do when considering a future telephone system expansion?

3. State two additional equipment management tasks.

2-2. Supervision

Supervision includes many factors. We learned in the introduction to this chapter that it consists of controlling, directing, commanding, and guiding. These functions are most applicable to people. Yet, we know that a supervisor is also responsible for materiel.

007. List typical duties for the telephone installation team supervisor.

We could describe *supervision* as it applies to all supervisors; for instance, a supervisor *must* be responsible for training his or her workers, for understanding industrial work motion analyses, for speaking to engineers in engineering language, and for solving administration problems. We know, however, that as a 5-level telephone equipment installation and repair specialist, you will not be performing all these duties.

Supervision of People. You may be a crew chief, in which case you will orient new crewmembers to the job, assign people to specific jobs on the crew, determine the quality of work that the workers are doing, resolve personnel problems, rotate your people. Jobs often are given a priority rating by management and you are responsible for seeing that your crew meets that requirement. Yet to do this, you may have to identify some procedures as having priority before the subsequent steps can be taken. Since the decision you make is not usually considered as a part of your regular functions, we are not identifying work priorities as a major task for 5-level airmen. We will look at the listed tasks briefly in the following paragraphs.

To improve the work quality of your people, you need to be confident, enthusiastic, impartial, and honest with your crew. If you are, your crew will respect you and they will probably be more cooperative. By being resourceful and friendly, you can make their work easier and more pleasant. Individual discussions with your workers can prevent many problems.

Exercise (007):

1. List four personnel tasks for a telephone installation crew chief.

008. Cite procedures a supervisor should follow in orienting a new worker.

Since the introduction period is your first opportunity to stimulate the new worker's interest in your organization and in the job, you should thoroughly prepare for the orientati and take sufficient time to welcome him or her.

New Worker Orientation. You should have an organizational chart available and a list of the duties. Further, make arrangements in advance for the tools, a locker, and any other equipment that the worker will be using. When the work arrives for duty, put him or her at ease by showing a personal interest. You can often do this by discussing interests, education, training, and work experience. A question about the worker's housing, transportation, and any off-base problems may likewise start the individual talking. Advise the individual of shortcuts that can be used to arrive at work more quickly and, if asked, of other ways in which time or money can be saved and probable irritations can be prevented.

Describe the organization while showing the organizational chart. Identify the position. Show a list of the duties and explain how the position relates to the other workers and their work and to the mission of the organization. Introduce the worker to the other workers and explain his or her duties. Show the worker the locker, the work area, and the available facilities. Introduce him or her to the tool manager.

Explain the shop rules and regulations; for example, duty hours, telephone restrictions, vehicle maintenance regulations, smoking restrictions, and clothing prohibitions. Stress safety and security. Tell also of the squadron functions and requirements.

Orientation Followup. Observe the worker's work methods closely. If they do not meet your standard, give step-by-step instructions for improving them. Encourage the worker to ask questions. Check on the worker's progress frequently. A new worker orientation also is often required when a person is assigned to another position. To illustrate, an airman assigned to assistant crew chief or temporarily as crew chief will need to be told about the new responsibilities.

Exercises (008):

1. List four things to do when preparing to interview a new worker.

2. List some probable subjects to discuss during a new worker's interview.

3. Give two actions of the new worker that will disclose a knowledge of the job.

009. Specify factors to consider when assigning workers.

Crew chiefs assign their people properly when they consider all the prevailing conditions. They must consider the experience of their people, the work that is to be done and its location, the priorities of the jobs, and the future projects.

Worker Assignment. You may divide your crew into two teams with an experienced worker and a helper on each team. In this manner, the helpers gain work experience for assuming responsibility of future projects. It is good practice, too, to divide the teams so that each team will do similar tasks and will do all the tasks in time. Yet, be cautious that their jobs do not overlap; because the workers may then fail to do the overlapping tasks and blame each other for the failure. Further, they could question your knowledge of the work for having made this error. You must know the work so that you do not assign more work than can possibly be done in a day. Your assignments must be clear and concise. If an emergency is reported, then you may have to assign your best people to the job. To make certain that urgent tasks are completed first, you identify them as priority tasks and assign your experienced workers to do them. Preliminary type tasks have also been considered as priority jobs, but all such tasks do not require an experienced telephone equipment installation and repair specialist. For instance, before you can attach a telephone set cord to a connecting block, you must first install the connecting block. Thus, we could say that this connecting block installa has priority over the telephone set connection.

Maybe a job is in a Top Secret area, which means that you would assign workers having this type clearance to that job The people you assign to the Top Secret area may also be assign to answer calls for similar telephone service in other offices in that area. All outdoor telephone service or equipment installation which requires the crewmembers to soil their clothes should likewise be assigned to crews wearing fatigues. Travel time and vehicle licenses are additional factors to consider when assigning crews. You may have a crewmember with an early appointment; consequently, you cannot assign him or her to a distant job. Secondly, you can't assign two crewmembers without drivers' licenses to a two-man crew which has to make service calls that are several miles from the work center. Again, then, you must know the qualifications of your workers and assign them accordingly.

Exercises (009):

1. Tell some work factors to consider when preparing to assign a worker.

2. Cite some worker characteristics to be considered when preparing to make crew assignments.

3. Give two job features to be considered when determining priority.

010. Name the work quality guide and specify methods used to insure conformance to it.

Work Quality Assurance. The installation and maintenance procedures used by the workers must meet the standards established by management. These standards have been proven effective through years of experience and through many safety analyses. To insure that these work standards are met, you must observe the workers while they are performing and note that they are using the available technical orders, using proven techniques, using safe methods, and are keeping the area clean. Also, be prepared to recommend and show correct procedures when you determine that a person's work is unacceptable. Follow up your recommendatio to see that the worker has made the change. (REMEMBER: All specialists who perform maintenance are to be evaluated by quality control. The evaluator rates each worker's performance of a task as satisfactory or unsatisfactory.)

Exercises (010):

1. What does management use to insure the work done by its people will be reliable and consistent?

2. List typical methods for seeing that the standards are being followed.

011. State considerations in planning for OJT.

If you determine that a worker's performance would be improved faster and more effectively through a training program, report this training need to the work center supervisor. He or she will arrange for an evaluation of the worker and the subsequent training. You may be asked to plan and conduct the training program. When preparing such a program, study AFR 50-23.

OJT Program Planning. Your OJT program planning must include answers to the following seven questions:

(1) How many training personnel need to be trained?

(2) How many people need training in equipment maintenance?

(3) How many installers need training?

(4) Which maintenance tasks require additional training?

(5) Which installation tasks require additional training?

(6) How soon must the training be started?

(7) What is the latest date permissible for the training to be completed?

To determine the number of personnel to be trained, you must find the number of people authorized for the organization now and in the future and how many of the workers have adequate time left in service for the training. Close observation of the worker's performance discloses the tasks needing additional training. The number of people available and qualified for doing the training is one factor that determines how soon you can start the training. Other factors that control the start date are the tools, test and telephone equipment, and facilities.

Exercises (011):

1. Tell two types of on-job-training with which a communications manager is concerned.

2. What is the usual method for determining that a worker needs on-the-job training?

3. List four factors that control the start date of an OJT program.

012. Cite procedures for conducting OJT.

On-the-Job Training Methods. AFR 50–23 tells about the training methods that should be used and the records you will keep. To illustrate, the four training methods described are lecture, discussion, demonstration, and performance.

With the OJT training methods, there are certain principles that will improve your instruction. For instance, for the trainee to learn, he or she must practice the task while you guide and advise. Be careful that you don't inform in a domineering manner. Insure, too, that the trainee sees how all the tasks to be completed fit into the completed job (the whole operation). Telling what is expected, emphasizing accuracy and safety, and relating the new material to subjects that he or she already knows are additional instructional rules to practice.

Motivate trainees by telling them how the training and their job performance will benefit them. Always tell each worker how he or she is doing and give credit for good work. Giving credit to the trainer may be shown with praise and a pat on the back. It can also be done by a special award or an appreciation letter. Credit to the trainee likewise may be shown with praise or encouragement and a pat on the back, or a special benefit—such as release from a task temporarily.

Constantly monitor the OJT program to determine its effectiveness. Visit the training area to observe the training and the workers' performances and ask questions of the people. Note the good and weak points and make recommendations for improvements. Follow up to determine if the recommendations were used and were effective. Keep records of the training and training results. You record on-the-job training results on AF Form 623, On-the-Job Training Record. The AF Form 623 must have a Job Proficiency Guide inserted within its covers. Usually the JPG is the STS annotated. If additional tasks are required to cover all the job's requirements, these supplemental tasks are listed and inserted in the AF Form 623. When the trainee qualifies on each specified task, encircle the code level in the appropriate skill-level column to indicate the task accomplishment. CDC, ECI, and other correspondence course completion is likewise shown on the AF Form 623. AFR 50–23 also describes the method for recording the certificates of training.

Exercises (012):

1. Name four training methods.

2. List some principles to use when demonstrating a lesson.

3. Tell things that an OJT trainer will do when monitoring a trainee.

4. What is the form number for the On-the-Job Training Record?

013. Name types of trainee evaluations and cite procedures for conducting these evaluations.

Worker Evaluation. A supervisor's evaluation of the trainee includes a review of the AF Form 623, a check on the trainee's progress toward completion of the CDC, and an observation of the trainee's performance while completing assigned tasks. The commander will also evaluate the trainee's progression. In addition, the commander will evaluate the adequacy of the training provided.

An additional training evaluation is the field evaluation of the Formal School Graduates Program. This program was ordered by USAF to determine the ability of each formal course graduate to perform the assigned tasks at his or her organization. This evaluation also should provide knowledge on which skills are performed every day by the airmen, how often they are performed, and at what level. The evaluation will reveal if there is a need for revision of the formal training course.

The evaluation is developed at the training center and may be of two types: (1) field visits and (2) questionnaires. Thus, as a field supervisor, you are asked to give honest answers to the evaluator's questions and to encourage the recent graduate to do likewise.

Furthermore, each graduate should be truthful when completing the CDC questionnaire following completion of the course. He or she should mail it to ECI within the specified period requested. An accurate evaluation will permit Air Training Command to recognize the needs of the personnel in the field and respond more quickly to help them.

Exercises (013):

1. Give the two types of evaluations of the Formal School Graduates Program.

2. What should a supervisor's evaluation of a trainee include?

014. State problem-solving steps and specify considerations for each step.

Solving Personal Problems. There are many personnel problems that you could have as the chief of a telephone installer crew. For example, you may have a specialist who resents an assignment or one who never takes proper care of tools and always makes installati mistakes. The same problems that you see as an installer crew chief can also be found with a telephone repair crew.

Most problems are not solved instantaneously with a sound solution. You normally must define the problem, establish your objectives, gather the facts about the problem, consider the possible actions that may be taken and the results of each action, and then make the decision. We will look at these problem-solving methods with a hypothetical problem.

Defining the problem. Let us think about Amn Jane Jones. She continually makes errors when installing telephones. Although we think we have seen the problem, is this the complete problem? To define the entire problem, you have to determine facts. You need to see if Airman Jones was using incorrect procedures, if she was in good health, if there were family problems, if she understood your instructions, or if the equipment was adequate, etc.

The first fact you can get by watching Airman Jones work. To determine whether her incorrect methods were taught by previous instructors or were developed by her after leaving the training section, you must question other people or go to the training school. To identify the state of her health and family circumstances, you must talk with Airman Jones. This type information may not be eas get. Maybe the hospital will have records that will show this information, but you must receive permission from Amn Jones and from higher authority to get it.

A discussion with her fellow workers may reveal some financial problems. Likewise, your other workers may disclose weaknesses in your instructions and in the equipment that has been issued to them.

Determining the objective. When you have learned the facts and noted the real problem, you can determine the objectives. Assuming that you learned that Airman Jones did not understand all the details of the job and that she also had defective equipment, we can identify objectives. To illustrate, to write instructions clearly and in detail and to request repair of tools or issuance of new toolkits to the workers would be objectives when such facts were noted.

We have noted that problem-solving consists of methods which relate. For example, we could not define the problem or determine the objectives without having facts. Each method, then, requires consideration of the others. Further, we found that all the facts could not be gotten from one person; you must also consult (coordinate) with other people.

Identifying the actions. We have said that after you have the facts, you should think about the actions and determine the results. We identified objectives for our sample problem; now we should identify actions that you could take and probable results. First, we said that detailed instructions should be written to reduce the worker's errors. Review these instructions to insure that they are always correct and maintains a file for the master copies. Considering the tool and equipment request, we know that this involves the organizational budget. If a tool or equipment is to be repaired, how can you continue to install and repair the customers' telephones when the tool is turned in for repair? Purchase of new equipment must be approved by your commander and by higher authority; thus, you must have good justification for your request. It takes additional time for you to write this justification. The tool table of allowance (TA) may also have to be changed to provide this authorization. Therefore, you will have to research AFR 0–10, *Management Control and Authorization Program of Allowance Source Codes for USAF Activities*.

Making a decision. Having looked at all these actions, make your decision. Delaying or failing to take action is a sign that you are avoiding your responsibility. Having taken the action, follow it up by monitoring the specialist's work again. (REMEMBER: You may not have had all the facts when you made the decision, or the decision may not have been the best solution. Therefore, your followup will let you be among the first to know it. Be honest, acknowledge your misjudgment, and be willing to look at all the facts again and to try another method to correct the problem.)

Exercises (014):

1. Cite steps useful in solving personnel problems.

2. State probable considerations when defining a worker's personal problem.

3. Give two example requirements for determining objectives.

4. What should be one of the first actions you take to reduce a worker's errors?

5. Once you've decided on a corrective action to remedy a worker's errors, what should you do next?

015. Specify procedures for reclassifying personnel.

Personnel Reclassification. If the worker does not improve his or her methods after being told of deficiencies, shown how to improve, and given retraining, recommend that the worker be reevaluated for certification. If the worker cannot be certified, the work center supervisor will submit a Personnel Action Request. You will probably be asked to provide some of the justification a classification board will require when reviewing the worker. AFM 30–3, Volume 1, *Personnel Data System*, has example forms completed to help you prepare a classificatio request. AFR 35–1, *Military Personnel Classification Policy*, describes classification board requirements and actions.

Exercises (015):

1. Identify two publications that have policies about personnel classification.

016. Specify a reason for rotating a worker and identify a type of training available to a specialist.

To keep your people proficient in all tasks of the career field (AFS), you should rotate them among related jobs.

Worker Rotation. If you have a specialist assigned temporarily to a position not in the normal progression pattern of the AFS, rotate the worker to review and renew his or her proficiency. Since the communications equipment of this career field is continuously becoming more complex, you also must prepare your workers for working with it by requesting training for them. This training may be provided by assignment to another base temporarily or to a base unit which has this equipment.

Looking again at figure 1-1, we can see that the telephone plant maintenance superintendent must know about tasks in four career ladders. We know that the maintenance superintendents can't know or do all the tasks for each of these AFSs, but they can have a broad understanding of the AFSs. They can get this understanding by cross-training or by temporarily working in or with those fields with which his AFSs are associated. In addition to working with people, you work with equipment.

Exercises (016):

1. For what reason are workers rotated to other jobs in this AFS?

2. What type training provides a specialist task knowledge of related career ladders?

017. Name equipment for which a telephone supervisor is responsible and cite typical installation crew chief tasks.

Supervision of Telephone Equipment and Assigned Vehicles. Each type of telephone equipment has troubles and trouble symptoms that apply only to it. Yet, it will also have troubles and symptoms of trouble that are common to other equip ment. Telephone crews do only limited vehicle maintenance. Major repair is left to vehicle shop personnel. Yet, they have the responsibility for using and caring for the assigned vehicle properly. Hence, we will look at both subjects in the following paragraphs.

Supervision of an installation includes planning, ordering authorized equipment, developing cutsheets, making schedules (determining priorities), writing instructions, observing and advising workers, revising installation procedures, and making and correcting records.

Your experience in installing and repairing telephone equipment helps you solve most equipment problems. Thus, by thinking about the former problems you have corrected, you can recall the methods which were most effective and reject those procedures which were unsatisfactory. Since technical orders and workcards list procedures, you must see that the work conforms to these directives. Although the installation and repair crews will do most of the work, you should know installation requirements and probable troubles and recognize the operational symptoms that result so that you can then advise the crewmembers.

Make a followup inspection after the installation is completed. Included in this inspection is a visual observation of the cables, strapping connections, KTUs, support frames, power equipment, and telephones. Also, check the system for proper operation. Each unit of the system must operate without failure during the check. The circuits must perform better than the minimum acceptable performance characteristic.

Satisfactory completion of the installation of a telephone system is acknowledged when the customer signs the work request; therefore, be sure that he or she has signed the service order before you leave his or her office.

Exercises (017):

1. Name Air Force equipment for which you will be responsible.

2. Identify supervisory tasks for the technician in charge of installing an Air Force-owned telephone equipment installation.

018. Cite supervisory tasks for a maintenance chief.

Supervision of Telephone Equipment Maintenance. Since maintenance includes inspecting, testing, servicing, and repairing and replacing equipment components, the supervisor of this crew will order the required equipment, make schedules, write instructions, observe and advise workers, revise repair and replacement procedures, and correct records. Further, as a supervisor, you will monitor the equipment technical orders and submit the proper form to get the errors corrected. Maintenance inspections should not disrupt the regular operations of the system. Keep a record of the discrepancies noted, the method by which they were corrected, and the date that they were corrected. These inspections and operational test procedures are described in the subsequent volumes; therefore, we will not describe them in this volume.

As a supervisor, you must emphasize safety with tools and test equipment when performing maintenance. Take note of the condition of the tools and equipment that you have. Make certain that your workers keep their units in good repair and that they use them properly. Look to see that the toolkit or kits and test equipment for the crew are on the truck before departing the work center. Also, insure that you have the required directives (technical orders, workcards, etc) and that the authorized spare parts are in the vehicle.

Inspect tools to see that they are stored properly. Check to see that they are in good condition. They should not be worn excessively, loose, bent, broken, or dented. Likewise, the test equipment should be inspected for proper storage; damaged meters; frayed, broken, or missing leads; low-voltage battery, and loose or broken controls. Return these tools, kits, and test equipment to their proper storage position.

Exercises (018):

1. List some tasks performed by a 36274 technician in charge of a key telephone system repair team.

2. Cite a final action for a crew chief before the crew departs the work center.

019. Compare tasks for supervisors of leased telephone and Air Force-owned telephone equipment.

The technician supervising leased telephone equipment must perform different tasks from that of a supervisor of Air Force-owned telephone equipment. The supervisor of leased equipment does not give directions to workers installing and maintaining equipment, but is responsible for coordinating with the Air Force consumers and with the commercial telephone company serving the base.

Supervision of Leased Telephone Equipment. To illustrate, an Air Force telephone user requesting a telephone change will submit the request to the telephone control office where this technician will determine if it is justified. Hence, the technician will check the records to insure that the telephone has the proper classification for such a change, that the proper form is used and that it is correctly completed. Also, the technician will look at the budget to insure that there are funds available. The technician will provide the findings to the communications officer who authorizes valid requests be granted. An approved service request is then submitted to the telephone company. The technician will complete and keep telephone service records as specified in AFM 100–22, *Management of Base Communications Facilities and Services.*

The technician may also review the monthly, quarterly, or annual charges from the telephone company and compare them to the Air Force records and verify that the local service billing and long distance statements were legal. This review for accuracy may be accomplished by representatives from both the base accounting and finance office and the telephone control office.

In addition, the technician will verify that the leased telephone equipment and the quality of service are adequate with an annual ON-PREMISE inspection. Likewise, the technician may study the telephone company records for the AUTOVON traffic in an effort to determine the average circuit holding time and the average number of circuits in use for the average workday or in the busiest hour. This information can be useful for improving the system usage. Secondly, the technician may monitor calls to insure that they are authorized.

Exercise (019):

1. Match each task in column A with the appropriate supervisor listed in column B. Some tasks may be performed by both supervisors.

	Column A	*Column B*
____	(1) Sets job priorities.	a. Supervisors of owned equipment.
____	(2) Analyzes circuit symptoms.	b. Supervisors of leased equipment.
____	(3) Plans activities.	
____	(4) Makes schedules.	
____	(5) Coordinates with technicians.	
____	(6) Writes instructions.	
____	(7) Gives advice.	
____	(8) Uses telephone records.	
____	(9) Directs crewmembers.	
____	(10) Evaluates work procedures.	

020. State safety procedures for driving telephone vehicles.

As a crew chief handling military vehicles, you must observe all laws and rules for operating vehicles and insure that your crewmembers also practice vehicle safety. Be a good example of "defensive driving." Some of the precautions which are based on defensive driving principles are disclosed in the following paragraphs.

Supervision During Vehicle Operation. Before backing the vehicle, be sure that the way is clear. Watch particularly for objects below your normal line of vision, such as children and bicycles. When a helper is available, have this person act as a spotter. Always give an adequate warning with the horn, lights, or any means at hand. Remember, many military vehicle accidents are caused by improper backing procedures.

Children are a great safety hazard. Always give bicycle riders plenty of room. You can never tell what they will do. Sound your horn well in advance of passing a person on a bike. Sounding the horn too close to the rider may startle him or her. Never permit bike riders to hitch on to your vehicle. Driv slowly when children are playing in or near the roadway. They may unexpectedly run in front of your truck. Stay alert and prepare to stop when you see a ball or other toy roll into the road. Use extreme care when driving near schools and school walk crossings and playgrounds. When traffic officers are present, cooperate with them. When you meet or overtake a schoolbus that has stopped to take on or discharge children, come to a complete stop and do not proceed until the bus is again in motion (or until the driver signals for you to proceed). Keep children away from your vehicle when loading or unloading materials.

While crossing bridges, stay in the designated traffic lanes. Be sure that there is ample clearance before going under a low bridge, through an underpass, or through an entrance with an overhead door. Never exceed bridge load limitations. During cold, wet weather use extreme caution—bridge surfaces freeze before highways freeze. When you are driving on ice or on snow-covered roads, use tire chains or snow tires. Do not expect too much of chains; they reduce the tendency to skid and provide increased traction for regular tires, but they do not provide the same degree of safety that regular tires have on dry roads. Remove tire chains when they are no longer needed.

You can avoid skidding by reducing your speed on wet and slippery roads. Skidding is often caused by rapid accelerating, turning, or braking and is more likely to occur on grades. To reduce the possibility of skidding when you are stopping, gradually apply the brakes without releasing the clutch until the vehicle is almost stopped. However, use care that you do not keep the engine engaged so long that it stalls. At the moment that your vehicle begins to skid, gradually turn the front wheels in the direction of the skid. It is better not to apply brakes or release the clutch until you have the vehicle under control.

Always have control of your vehicle. Remember, it takes time to stop a vehicle. The information in table 2-1 shows the time that it takes for a car to go specific distances at certain speeds. To illustrate, a car traveling at 10 miles per hour goes 15 feet each second. Thus, in 1 minute it will cover 900 feet (approximately 1/6 of a mile). Remember that this table concerns passenger cars. The Air Force equipment you drive is much heavier. Therefore, you will need more time to stop your vehicle. Drive at a rate of speed appropriate to the flow of traffic, surface conditions, width of the road, existing conditions and restrictions, and weather. Be ready for any unexpected action on the part of other drivers and pedestrians. Keep pace with the moving traffic (within speed limits). Avoid cutting in or out unnecessarily. Stay in line—in your lane. Do not force other drivers to cut in or out unnecessarily. Drive slowly around curves and keep to the shoulder or curb side of your side of the road. Never try to overtake and pass another vehicle on a curve. Do not make U-turns or park on or near a curve. Never cross a solid line in your lane or a double solid line (strip) in the center of the roadway; these markings indicate a no-passing zone. Drive in a careful and considerate manner and at a rate of speed that does not endanger the property of others or the life of any person.

While driving, let nothing distract you. If a bee, wasp, or other insect enters the vehicle, bring the vehicle to a stop before attempting to remove the insect.

Many accidents are caused by improper passing procedures. Before changing lanes to pass another vehicle, look to the rear and sides. Someone may be trying to pass you; don't speed up. Keep to your side of the highway and let him or her pass. After having passed a vehicle, be careful when pulling into that vehicle's lane. Never pass another vehicle while you are ascending or descending a hill where your vision is obstructed. Keep to your side of the road and reduce speed when approaching the crest of a hill. Before you descend a steep grade, shift to a lower gear. Let the engine do most of the braking. Apply brakes carefully. This helps to avoid skids, and the brakes remain cooler. When you must stop in traffic, come to nearly a complete stop several feet behind the car or vehicle ahead; then roll forward to a full stop just behind the car ahead.

Before changing or entering a traffic lane, stopping, slowing, and making turns, give the proper signal well in advance. Giving a signal does not guarantee the right-of-way. Watch for signals given by other drivers and be prepared for any action they may take. Proper signals are not only a courtesy and an important factor in the safe operation of a motor vehicle, they are required by law.

Overtaking and passing should never be attempted at railroad crossings and intersections. Always approach an intersection at a controlled speed that will enable you to avoid a collision regardless of the action of any other driver or pedestrian. Do not depend entirely on traffic signals and stops; the other driver may ignore them. Always give pedestrians the right-of-way. Avoid backing into an intersection—go around the block instead.

Allow enough distance between your vehicle and the one ahead so that you can foresee trouble. Experience has shown that a following distance equal to one vehicle length for every 10 miles of speed is a safe distance under most conditions. For example, at 30 miles per hour, allow a distance of at least three vehicle lengths between vehicles. This rule is only a guide for driving safely. Table 2-2 shows stopping distances on dry pavement. The table is based on a reaction time of 3/4 of a second and the braking distances within which your brake will stop the vehicle. Of course, you realize that stopping distances increase substantially when the pavement is wet with rain, snow, oil, mud, or ice. Hence, you should allow a substantially greater clearance between vehicles. Apply the brakes with an intermittent pumping action.

Be prepared for glare (uncontrollable brilliant light) when driving. The use of sunglasses and sunvisors may help to

TABLE 2-1

VEHICLE MOVING DISTANCES

A car moving at the rate of:

10 mph travels 15 feet per second
15 mph travels 22 feet per second
20 mph travels 30 feet per second
25 mph travels 37 feet per second
30 mph travels 44 feet per second
35 mph travels 51 feet per second
40 mph travels 59 feet per second
45 mph travels 66 feet per second
50 mph travels 73 feet per second
60 mph travels 88 feet per second

TABLE 2-2

VEHICLE STOPPING DISTANCES ON DRY PAVEMENT

Speed in MPH	Distance Reaction in Feet	Breaking Distance in Feet	Total Stopping Distance on Dry Pavement in Feet
20	22	19	41
30	33	43	76
40	44	76	120
50	55	119	174
60	66	171	237

reduce this glare, but if you do, use great care and caution since they restrict your vision. Keeping your windshield clean also reduces the glare.

Keep a safe distance from objects that extend beyond the curb or from other vehicles. When opening or closing vehicle doors, keep your hands off the glass and see that the hands and fingers of your passengers are in the clear. When opening a door of the vehicle, be careful of passing pedestrians and other vehicles.

Keep the floor of your vehicle clean. Dirt and dust can blow around the vehicle and into your eyes when the windows and ventilators are open while you're driving. If you become drowsy while driving, stop. Do not proceed until you have rested. Avoid driving while you are excited or nervous. Don't drive while drinking or drink while driving. Obey all traffic control and warning devices in the following order of precedence:

a. Policeman or policewoman or other persons directing traffic.
b. Traffic lights.
c. Signs.

Need for caution is even greater with night driving since darkness increases the dangers. The first thing you should do is slow down. Follow the posted speed limits. Never drive without proper vehicle lighting. Make certain that ladders, tarpaulins, or other equipment do not obscure the running lights. When preparing to meet an oncoming vehicle, switch to low-beam headlights and gaze toward the extreme right-hand side of the road. If the approaching vehicle fails to switch to low beam, slow down and keep as far to the right as possible. When following a vehicle, keep your headlights on low beam. While driving in fog, drive slowly on the outer edge at your side of the road. Drive with low-beam headlights. The high beams are reflected by the fog, and they interfere with your vision. If you cannot see any road ahead of your vehicle, stop. If you must stop on the highway, use flasher lamps or keep your parking lights ON. Place flares about 100 feet ahead and behind the vehicle. If you work around the vehicle, do not block the front or rear lights.

Exercises (020):

1. Give two safe driving practices when backing a truck.

2. Identify three safety requirements for driving in an area where there are children.

3. Specify two driver actions to use at a bridge.

4. State two control procedures for a skidding vehicle.

5. Give four safety rules for driving on an expressway.

6. State three safe passing rules.

7. Specify the act required of drivers whenever they are preparing to change their driving situation.

8. Give two rules for safety at an intersection.

9. Give the distance ratio for a vehicle following another.

10. State the rule for drinking and driving.

11. Identify some safety requirements for driving at night.

021. Cite acceptable procedures for parking an Air Force truck.

Park on a level spot wherever possible. When parking on a grade, observe the following four rules:

(1) Position the rear wheels close to the curb and then the front wheels into the curb. Chock the wheels, if necessary.
(2) Set the hand or parking brake.
(3) Stop the engine.
(4) Place the vehicle gearshift in reverse.

Where practicable, park off the traveled portion of the road and take precautions to warn the approaching traffic. Except in emergencies, NEVER park:

- Near intersections.
- At the top or bottom of hills.
- In front of or across from driveways.
- On or near curves.
- Near construction work.

Park your truck on the side of the street or highway in a manner that prevents you from having to cross the street to get tools and materials. Enter and leave your vehicle at the curb side.

Before you pull out from the curb, be certain that you have your safety belt fastened and that there is clearance in front of your vehicle. If necessary, back up to get the necessary clearance. Give the correct signal to show your intent. While pulling out, look at the traffic of the street. Wait for an opening for your vehicle before entering the traffi Continue to watch the other vehicles while you are pulling into the traffic.

Exercises (021):

1. Give four procedures for parking on a grade.

2. Identify the proper method of leaving a vehicle parked beside a busy street.

3. State two rules for pulling out from the curb into the street.

022. State maintenance procedures for Air Force vehicle operators.

Unit and organizational commanders are required to insure that vehicles issued or assigned to their commands are properly maintained and are properly used. Accordingly, crew chiefs and vehicle operators are made responsible for the vehicles assigned to them. In discussing vehicle care and operator maintanenace, we will refer to it as "preventive maintenance." The purpose of preventive maintenance is to assure maximum operational readiness. A careful driver also takes good care of the vehicle.

Supervision of Vehicle Operator Maintenance. The vehicle operational and maintenance regulation identifies the inspections required for Air Force vehicles. Included are the daily, scheduled, safety, special, technical, and acceptance inspections. You are only concerned with the daily inspection because it is to be performed by all operators of Air Force vehicles. There is a specific form that you will complete when you operate such a vehicle, but we are not identifying the form because form numbers are often changed. On the subject form that you will check are these example items: condition of the tires, windshield wipers, horn, brakes, lights, and cleanliness of the vehicle and battery. You must also indicate on the form the level of the fuel and record all discrepancies. If maintenance is required, do not defer returning the vehicle to the control office for that maintenance. Your signature on the report denotes that your inspection found the vehicle to be satisfactory.

Systematically inspect your assigned vehicle daily. In this way you can uncover defects before they result in serious damage or failure. Your daily inspection can be divided into three parts: (1) before-operation service, (2) during-operation service, and (3) after-operation service.

The before-operation service consists of checking to see if the vehicle conditions have changed since the last after-operation service. For example, try the brakes before you leave the parking area. Test the operation of the operational signals, headlights, stoplights, and taillights. Note if the mirrors and window glass are clean. Adjust the mirrors. Remove any unauthorized stickers, paper, or other obstructions to your vision. Operate the windshield wipers. Check your tire tread and pressure. Inflate the tires to the proper pressure.

The during-operation service consists of detecting unsatisfactory vehicle performance while driving. Be alert for any unusual noises and odors, abnormal instrument readings, steering irregularities, and any other indication of trouble. Each time you apply brakes, shift gears, and turn the vehicle, note any unusual or unsatisfactory performance.

The after-operation service permits your vehicle to be ready for instant use. Thus, see that it is refueled and clean. Correct, insofar as possible, any operating deficiency. Report to organizational maintenance personnel any defect that requires repair or replacement.

Specific procedures for preventive maintenance differ from one organization to another. However, they all follow applicable technical order procedures. We are mentioning only example maintenance specifics here; you must study your own organization's directives for a more complete coverage of your equipment.

Tires are of utmost concern to the vehicle operator. Bear in mind that as the tire tread wears down, the tendency toward blowouts, flats, and skidding increases and requires greater driving care. If you have a flat tire, follow these instructions. First, position the vehicle on level ground and shut off the engine. Place the gearshift into an engaged position and set the handbrake. Get the jack, jack handle, and lug nut wrench from the tool compartment. Loosen the lug nuts on the wheel. at this point, DO NOT REMOVE the lug nuts. Place the jack under the axle housing and raise the vehicle until the wheel clears the ground. Now remove the lug nuts and lift off the wheel. Install the spare tire using the same procedures but in reverse order. At the earliest opportunity, check and inflate the tires to the proper pressure and have the deflated tire repaired.

Detect valve core leaks by removing the valve cap and applying a small amount of water over the valve core. If bubbles appear, tighten the valve core or repair or replace it.

Check battery level by removing the filler caps and noting the electrolyte level. If it is below the fill mark, add water. Use distilled water if it is available. Also, be certain that the water is clean and free of debris.

To drain the cooling system, run the engine at a fast idle until the normal operating temperature is reached. This action stirs up any loose rust or scale. Stop the engine. Open the radiator draincock and remove the radiator cap. Open the engine block draincock located near the right side of the engine and permit the fluid to drain.

To refill the cooling system, close the engine and radiator draincocks. At this point we should add a word of caution: Do not pour cold water into the cooling system if the engine temperature is above 200° F. Fill the system to suit the climatic conditions prescribed by your organization. Install the radiator cap, making sure that the filler gasket is in good condition. Start the engine and run it at a fast idle until the temperature gauge indicates normal operating temperature. Stop the engine and check the coolant level. Add coolant, if necessary.

Keep in mind that a good preventive maintenance and corrective maintenance program provides a trouble-free vehicle. Your responsibility includes minor adjustments, maintenance, and emergency removal and installation procedures.

Many accidents or near misses have been caused by the failure of the operator to inspect parts and correct defects routinely. Preventive maintenance is simple maintenance when performed daily. Although you may be a safe driver, you do not deserve any award if you fail to care for your vehicle properly. Safe driving is mostly commonsense and courtesy.

Exercises (022):

1. List some operator tasks to perform before operating an Air Force truck.

2. Specify three conditions to look for during the operation of an Air Force vehicle.

3. State the two usual actions required for an Air Force vehicle following a maintenance trip to a distant satellite station.

4. List some vehicle operator tasks that may be considered as preventive maintenance procedures.

CHAPTER 3

Security

EACH OF US strengthens the Air Force when we use good security procedures. We do this when we realize what must be done to insure security. However, many people fail to recognize a real or potential violation unless it is clearly evident.

To insure that you strengthen the Air Force rather than weaken it, learn the regulations. With this knowledge, you should be able to act quickly when a violation is evident. (REMEMBER: The security police alone can't maintain security. They are called only after a violation is suspected or has been committed.)

This chapter will not identify all of the security publications nor will it duplicate the information contained in those that are cited. However, a careful study of it provides a review of the information of these publications.

You—and only you—can protect the military information of which you have knowledge. Keep this thought in mind wherever you go: Rules are the tools we have to help us do a job well, and the rules applicable to safeguarding classified information are the same throughout the Air Force.

3-1. Communications Security (COMSEC)

Communications security is all the precautionary measures designed to deny unauthorized persons information of value which might be derived from possession and study of telecommunications or to mislead unauthorized persons in their interpretation of the results of such a study. All defense information is characterized as: (1) unclassified official information, and (2) classified official information. Each of these has varied degrees of its own classification. To develop a "security conscious" attitude, you should know the purpose of the Air Force security program, know security publications, and know methods for protecting information.

023. Identify the types of information provided by security publications and clarify examples of official information.

The purpose of security is to protect or safeguard United States Government information. Thus, you must keep official information from people not authorized to have it. You learned this purpose in the resident course. Also, you should recall from that course some of the security publications that describe controls for the organizational programs.

Security Publications. The first regulation which you should recall is DOD 5200.1–R, *Department of Defense Information Security Program Regulation*. It describes the classification, declassification, downgrading, and safeguarding of official information. However, with each DOD 5200.1–R regulation you will find an AFR 205– 1, *Information Security Program*. This Air Force regulation provides additional security information for Air Force personnel. You should use both regulations together. For example, the security classification categories are described in DOD 5200.1–R; therefore, this information is not found in AFR 205–1. This Air Force regulation provides specific instructions about requesting classification action and for requesting additional classifiers.

Additional publications which you may be required to be familiar with are AFR 205–37 and AFR 205–57. AFR 205–37, *Security Classification Guides*, has a standard format for use in preparing security classification guides. AFR 205–57, *Reporting and Investigating Espionage, Sabotage, Terrorism, and Subversion*, describes the threat to the United States Air Force posed by hostile, overt, covert, and clandestine activities. It also establishes procedures for: (1) reporting and investigating all allegations or incidents which pertain to those activities and (2) for briefing on this threat.

You may have to study other publications to keep current with security requirements for your job. For now, let's again review the classification categories.

Categories of Official Information. We said in the first paragraph of this section that official information is characterized. Since the classified information requires protection, it is given only to persons having clearance. These people have been identified as having a "need-to-know." The unclassified official information does not require extensive protection but must be controlled. In other words, it is information that will not be given to the general public. You have seen that technical orders are necessary Department of Defense references and are identified For Official Use Only. Thus, they have unclassified information which is for the use of Department of Defense personnel only.

To help you review the different classifications, we have included a classification guide as figure 3-1. At the top of this figure are the three secure categories and a For Official Use Only heading. To the left of the illustration are listed five types of information. Using this classification guide and working with the 400D KTU AND 1A2 equipment, under

	I Classify TOP SECRET if disclosure could:	II Classify SECRET if disclosure could:	III Classify CONFIDENTIAL if disclosure could:	IV Mark FOR OFFICIAL USE ONLY if disclosure could:
A Intelligence Efforts	reveal own success and/or capabilities by allowing full evaluation of effort.	reveal facts we know: potential enemy material, troop disposition, etc.	compromise some intelligence and counter intelligence reports.	reveal information furnished by foreign nations in confidence.
B Weapon Systems	(1) disclose nuclear data, (2) compromise radically new and extremely important equipment.	compromise data relating to new developments.	reveal production and procurement of munitions some technical training manuals.	reveal certain technical data relating to arms which are subject to export licensing.
C Force composition and Deployment	compromise world-wide composition and deployment in war plans.	reveal strength, identity, equipment, composition, and location of units engaged in hostilities.	reveal strength of ground, naval, and air forces in the U. S. and overseas.	reveal information pertaining to specific unit identification, current location, and general nature of equipment. orders to an area of undeclared war.
D Political-Military Information	(1) lead to a definite break in diplomatic relations, (2) result in an armed attack against the U. S. or its allies.	jeopardize international relations.		
E Operations	compromise strategic plan documenting overall conduct of war.	compromise plans that reveal military capability or preparedness.	reveal operational and technical doctrine/ radio frequencies and call signs of special significance.	

JA-008

Figure 3–1. Example classification guide.

what classification would you place the information about this equipment?

Since this is technical data applicable to transistorized key equipment, it relates best with the For Official Use Only heading. You should recall that all military and defense information falls into this category. However, other technical material not included in one of the classified categories may also be considered under this category.

Your study of the information in the Top Secret column of text figure 3-1 should reveal that, if it were known by an enemy, it could result in exceptionally grave damage to the national security. Thus, it could result in a break in diplomatic relations and/or result in a declaration of war.

Analysis of the Secret column in figure 3-1 reveals that disclosure of this information could result in serious damage to the national security. That is, it would jeopardize the United States' international relations and compromise military plans or technical data about new defense programs. The arrow shows that weapons systems information that compromises data is Secret information.

The Confidential column (column III) has information which, if known by an enemy, would also result in damage to the national security. Of course, this damage is not as critical as that caused by the disclosure of Top Secret or Secret information.

The classification of information is one of the procedures for providing security for America. Additional procedures are described in the following sections.

Exercises (023):

1. Identify the publication to which each statement applies.

____________a. Has a standard format for use in preparing security classification guides.

____________b. Describes classification, declassification, downgrading, and safeguarding of official information.

____________c. Describes the threat to the USAF posed by hostile, overt, covert, and clandestine activities.

2. In what category should this CDC be placed?

3. What type of information is the illustrated parts breakdown for the 302 switch units?

4. How should the target for a laser bombing attack during a wartime action be classified?

024. Cite examples of essential elements of friendly information (EEFIs).

Essential Elements of Friendly Information. EEFI includes those types of categories of information about a plan, project, or activity which, if acquired by hostile units, may jeopardize the successful execution of an operation.

EEFIs provide guidance which helps to prevent the disclosure of information of possible intelligence value. People trained in communications security use them to evaluate the security position of friendly forces. EEFIs are also used to assess the operational risks that may result if an unfriendly force has a prior knowledge or awareness of a condition. Each major command and separate operating agency develops EEFIs to meet its operational requirements. The following list provides examples of EEFIs:

(1) Introduction of new equipment.
(2) Shortages or deficiencies in equipment.
(3) Specific personnel shortages.
(4) Security clearances of individuals.
(5) Changes in unit mission or its organization.
(6) Important official visitors and their itinerary.
(7) Project or activity nicknames.
(8) Identity and location of defense units.

Exercises 024):

1. Give two possible EEFIs for equipment.

2. Identify two possible EEFIs for personnel.

3. Cite one change that could be an example of an EEFI.

025. Cite procedures and requirements for handling, storing, removing, and destroying classified material.

Full security exists when only one person knows classified information. In such a case, the information would not need to be recorded. However, for Government operations, we know that full security is extremely difficult to obtain, because the information MUST be used by more than one person. Consequently, the following procedures are some which you must use to safeguard classified information.

Handling and Storage of Classified Material. When assigned to an office that has secure storage facilities, learn the handling procedures. Be sure that the storage unit has only classified documents in it; do not place nor permit anyone to place unclassified documents or articles in the unit. At the end of normal duty hours, inspect the storage unit to insure that it is properly locked. Additional requirements are described in DOD 5200.1–R and AFR 205–1.

Removal of Classified Material. Learn the name of the person responsible for the storage unit. Receive permission before removing classified material from the locked container and be sure and sign the record form attached to that unit. This record will show the name of the person using the classified document, the date that you took the document, the title of the document, the classification of the document, the purpose of its removal, and the name of the person who authorized its removal. Of course, you must return the material to the safe and note this action on the record. Further, review the security regulations regularly so you will be aware of any changes in the requirements.

Destruction of Classfied Material. Since you may not be involved in the destruction of classified material, you won't be expected to learn the specific procedures. You should know, however, that these procedures are described in specific regulations. AFM 12–50, *Disposition of Air Force Documentation*, names the authority for destroying classified material; and DOD 5200.1–R and AFR 205–1 provide the procedures for normal, special, and emergency destruction of information. Remember that the destruction method (burning or mutilation) must be sufficient to preclude recognition or reconstruction of the classified information.

Each command publishes a standing Emergency Destruction Plan, and all personnel should be familiar with it. In case of attack or in some situation requiring immediate destruction of all equipment, be familiar with your unit's destruction plans and procedures.

Safeguards are also required when transferring voice and written messages. We will review those in the following section.

Exercises (025):

1. State two requirements you must observe when working in a classified material storage area.

2. Give two requirements you must observe when preparing to use classified material.

3. What is the most important factor in the destruction of classified material?

026. Specify procedures for transmitting classified material.

Transmitting Classified Material. The method of transmitting a piece of classified material between offices depends largely upon its classification. Some examples of the procedures used for the different classifications are:

a. Top Secret material is transmitted within a headquarters by Top Secret control officers or by certain selected people. Outside of a headquarters, Top Secret material requires the use of special messengers; it cannot be transmitted by mail. Neither can Top Secret material be sent in clear text by electrical means.

b. Secret material must be transmitted between staff activities within a headquarters with as much security as if it were being transmitted outside the headquarters. Under ordinary circumstances, Secret documents do not require special enveloping when transmitted within a headquarters, if they are properly protected. But if the individual carrying the classified document does not require access to it, the document must be inclosed in an opaque cover. Of course, only military and civilian personnel known to be reliable and trustworthy are used to transmit classified material. For tranmission outside a headquarters, Secret and Confidential materials are inclosed in opaque inner and outer covers. The inner cover is a sealed envelope or wrapper, or other appropriate container for material too bulky for wrapping. This wrapper is addressed, return-addressed, and plainly marked with its classification. When a receipt is required, it must be inside the inner cover. The outer cover bears the address and return address, but it has no markings or notations to indicate the classification of the contents. If necessary, paper must be wrapped around the inner cover so that its markings cannot be seen through the outer cover. The outer cover is carefully sealed. Wrapped or packaged mail matter must be sufficiently secure to prevent damage to the container and possible exposure of classified information while it is in transit.

c. Confidential material normally requires only a single sealed envelope or container. There are no markings showing the classification or specifically identifying the contents unless it is to be sent by diplomatic pouch. Outside a headquarters, Secret and Confidential material, except for certain material specified in DOD 5200.1-R and AFR 205-1, is transmitted by the most appropriate available and authorized means to insure that the information will be accorded the proper degree of protection. Within the continental United States, Confidential material (except material addressed to APO addresses and other similar addresses) may be sent by certified or first-class mail, while Secret material must be sent by registered mail.

A written classified message may be sent by electrical circuits only if it is coded. Text figure 3-2 illustrates a sample noncoded message and coded characters for the message. (NOTE: This is only a sample.) The coding method is Secret. You have learned in the resident course that encryption is a form of telecommunication. That is, it is a form of transmission of intelligence. This communication may be by wire (electromagnetic means) or by radio. For our purpose we are identifying these communication methods as voice messages.

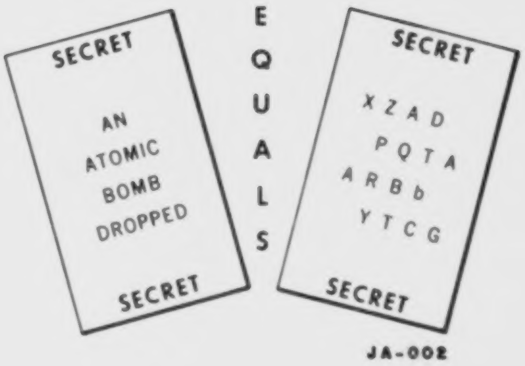


Figure 3-2. Sample noncoded and coded message.

Exercises (026):

1. Tell the two methods for transferring the Top Secret information.

2. How would Secret material be transported from Seattle, Washington, to Palm Beach, Florida?

3. What type of classified message may be sent by first-class mail?

027. Identify common telephone violations and state why telephone calls should concern you.

Although the telephone is probably the most convenient means to thoroughly discuss a problem, it is the one means least likely to be secure. The following information highlights the dangers of improper use of the telephone.

Types of Calls. There are—first of all—on-base calls or calls from some other office. We feel safe about these. They are "all in the family." Then there is the "Washington calling," pictured in figure 3-3, or some other higher headquarters situation, or possibly a call from one of our own distant units needing information. The mystery of the long distance call, even in this modern age, still gives a special urgency to providing information to the caller. Thinking seems to run something like this: If it is important enough for him or her to call long distance, I'd better give him or her the information.

Then, there are the off-base, out-of-the-family calls from the press, local organizations, individuals, and credit or personal reference organizations. Thousands of these calls are received daily. We all know that we do not give these

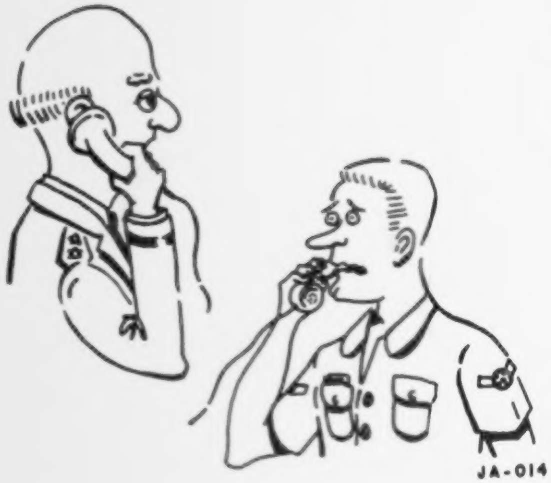


Figure 3–3. "Washington calling."

persons any information. But what happens when we leave the receiver off the hook, as shown in figure 3-4? All the person on the other end has to do is listen! This person may not get the information he or she has asked for, but what he or she does get may be many times more valuable.

Common Telephone Violations. The following are some specific examples of reported violations.

Example No. 1. Amn Bob Smith was very familiar with certain classified terms and phrases. It was alright for him to discuss classified information with his coworkers inside the exclusion area where he worked. But one day while answering the telephone, he replied to a coworker's question, using a classified term which he should not have used over a telephone.

Example No. 2. A unit clerk was trying to prepare a report for the unit, but some of the information she needed had not been turned in. She couldn't wait any longer, so she called the person who had the information. The clerk knew the information in the report was classified. She also knew that, "It is permissible to refer to classified material over the telephone, provided that such references do not reveal the classified portion." (For example: You may refer to the file number, date, and the subject—provided the subject itself is not classified.) The clerk also knew that each individual must make sure that neither the questions nor their answers reveal classified information. Was the subject classified? She was not sure. She cited the reports control number, the due date, and the title of the report. In this case, the title was classified a violation.

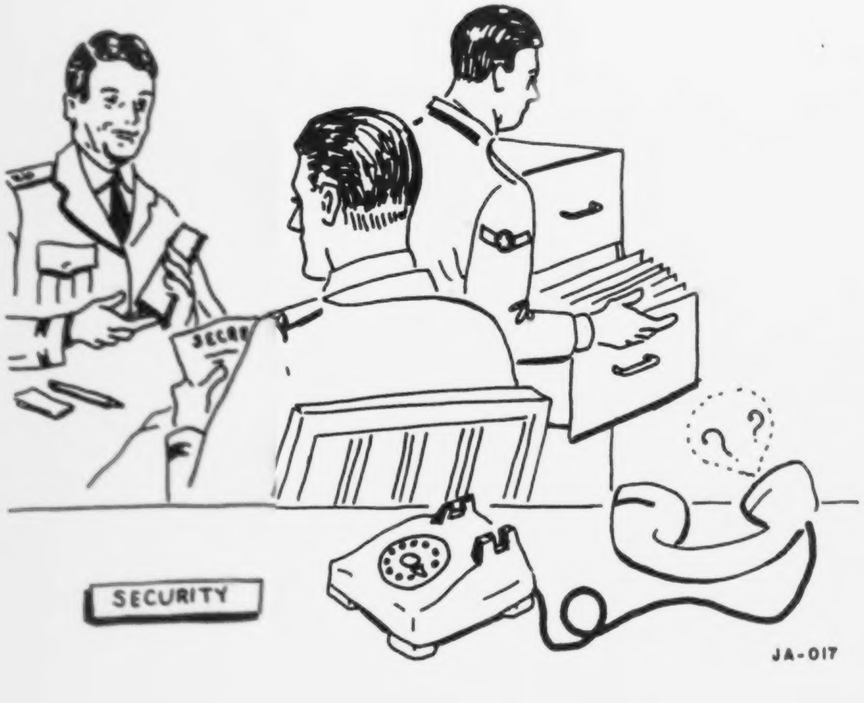


Figure 3–4. Example of a security violation.

Example No. 3. The secretary was new in her position. When the telephone rang and a pleasant voice said "Good morning, this is so-and-so," she recognized him as a VIP. When he asked for some facts and figures, she realized the information was Secret. What should she do? Her train of thought ran something like this, 'They say we are not supposed to give classified information over the telephone—but this is an important man and he has been here much longer than I have. Surely he wouldn't ask for this information over the telephone if it weren't all right. I'm sure he knows what he is doing, and he must be in a hurry for it. Maybe I should ask someone.' She looked around the office, but there was no one to ask; she was all alone. "I was taken by surprise," she told the investigating officer. That's why I gave him the information. Almost every day someone asks for information which should not be discussed over the telephone. The security-wise person says something like, "If you will come by the office, we can supply you with the information." DON'T PANIC. Even over long distance, a requester must be told " I can't give you that information over the telephone, but we can send it to you by letter or by message."

Human Error. From our discussion, especially from the examples, you know that the weakest link in the security chain is the human. Humans are especially dangerous because, in spite of all regulations, knowledge of those regulations, and constant reminders, their weaknesses still cause most telephone violations. The examples already mentioned are only some of the violations which have been reported in the past. They were included in the hope that we may learn from the mistakes of others.

A word of caution! In the past, we have heard of people who seemed to pride themselves in being able to "talk around" classified subjects—they thought! Well, it just can't be done—successfully. You may think you can, but the only person you are fooling is yourself.

Let's suppose for a moment that you do make a telephone call and that you do successfully "talk around" one aspect of a classified project pertaining to your area of interest. Now look at figure 3-5. The "man in the center" has the answers too. What do you suppose would happen to the security of the project if dozens of people discussed their interest in the same project, and each excluded only the classified portion of it? Answer: By the time several different people had put in their "two cents worth" about something, it wouldn't take a very sharp analyst to 'add up' most of the details about it.

Exercises (027):

1. Why does a long-distance official incoming call require good judgment by the receiving individual?

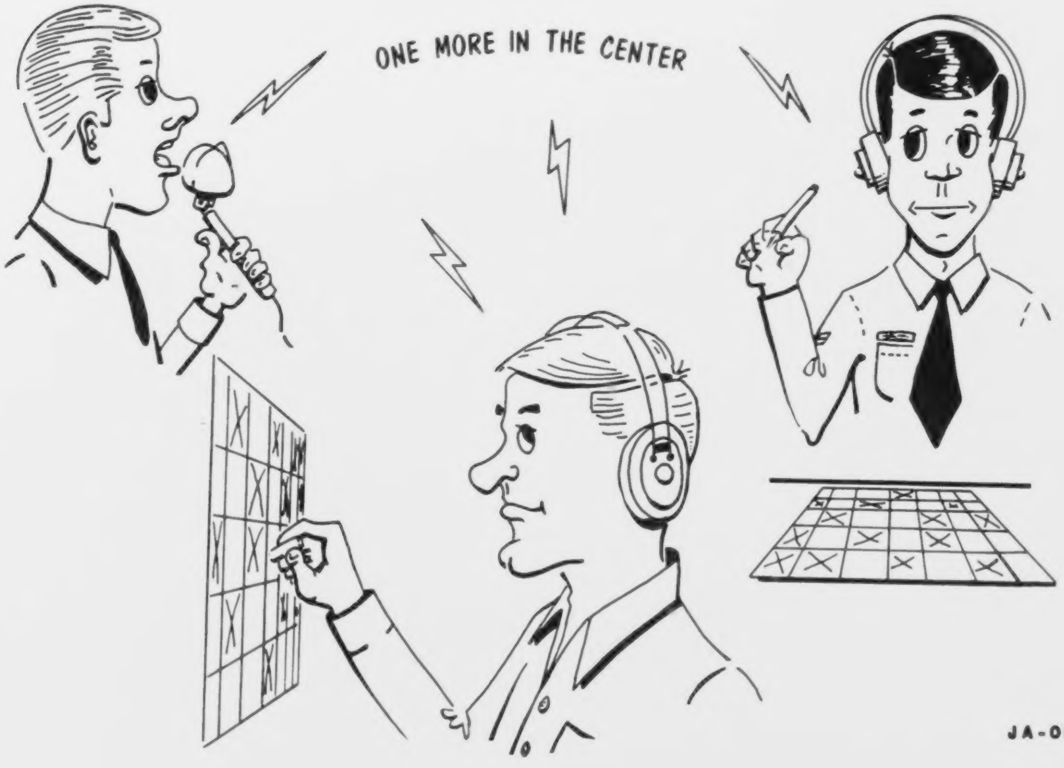

ONE MORE IN THE CENTER
JA-016

Figure 3–5. "Let's around talk about it."

2. In example 1, what was the individual's first mistake?

3. From your study of examples 2 and 3, give the precaution you should use to insure that official information will not be disclosed.

4. Is it permissible to inform your caller over the telephone that the information requested is classified? Explain the correct response.

5. Is it permissible to "talk around" a classified subject? Why?

3-2. Operational Security (OPSEC)

Operational security (OPSEC) is those actions taken to deny information about Department of Defense operations to unfriendly/hostile nations. These actions must be the concern of all Air Force and other Department of Defense personnel.

028. Relate OPSEC to other security programs, list the four operational phases in which it should be used, and identify its vulnerabilities.

OPSEC, COMSEC, information security, and physical security are interrelated and support each other because they are all protective actions. Physical security consists of the actions taken to safeguard classified equipment. Information security is all the actions taken to safeguard classified material and documents. COMSEC includes communications procedures that purposely mislead as well as the procedures that withhold information from people not authorized to know. OPSEC also involves actions that affect communications, but it is described as having broader application. It is to be used for an entire program; that is, it is to be used during the planning phase, during the developmental period, during and after completion of each operational period, and with the follow-on stages (critique and reporting phases).

Areas of OPSEC concern, because they are areas where people often fail to use safe procedures, are: operations, communications, and routine functions.

Operations. Doing operational exercises in the same way time-after-time is a dangerous practice, for it enables a monitor to easily determine the pattern or program. By changing the procedures intermittently, the operational personnel keep an exercise more secure. Also, sudden changes in requests give clues about planned exercises. To illustrate: An immediate request for an increase in arms, ammunition, air transportation, field rations, immunizations, etc., indicates a new exercise is scheduled.

Communications. Security of voice communications is a major OPSEC concern. Most conversations using electronic equipment are insecure—that is, they are made while using a telephone or radio and without the use of secret codes (encrypted). Furthermore, each conversation about military activities has the potential for compromise. It can be received by foreign satellites circling the earth or on antennas of foreign ships near the coast, or by intelligence agents stationed near specific military installations for the purpose of monitoring discussions.

In the area of communications equipment maintenance, you also must be concerned with security. Since some equipment circuits are highly classified, be careful how you report outages for them, and also be cautious when and how you perform the maintenance.

This means that while you are maintaining telephone equipment, you also are responsible for the protection of information being transmitted. For example, when you test live (active) circuits during maintenance operations, you by necessity have access to circuits which may be in use for transmitting information related to the safety and security of the national security. When you monitor a working circuit to determine whether it is in use, you have no right: (1) to know the information you overhear, (2) to continue to eavesdrop on the conversation, or (3) to repeat the information. It is unlikely that you will knowingly be placed in the position of working on a live circuit used for military command or staff communications at any organizational level; but if this should ever happen to you, get off the line and stay off as long as it is busy. This is, of course, the action that you should take whenever you find a circuit in use, regardless of your job.

In addition, when requesting command assistance, use care that you don't disclose sensitive information and when documenting the maintenance actions, enter only the required information. Lastly, be careful of what you say and to whom you say it when discussing your job with other

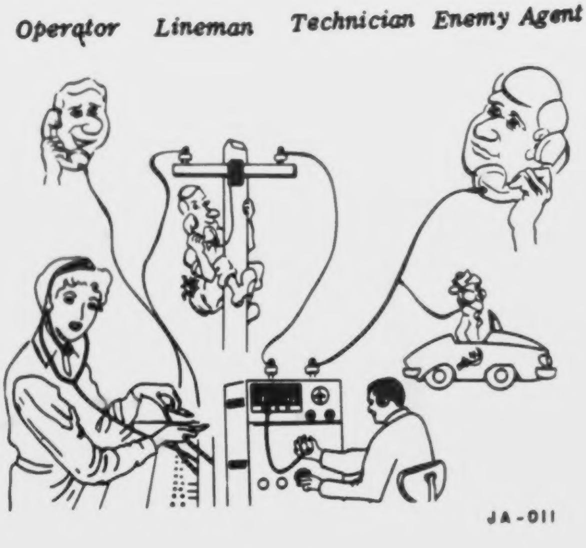


Figure 3–6. Are you guilty?

people. Be sure that the people you talk with have a need to know and have been cleared to receive classified information.

Routine Functions. Routine activities often reveal significant intelligence information, thereby alerting unfriendly analysts to place more attention toward that command. For example, schedules posted on bulletin boards, releases to base or local newspapers, and comments made to friendly civilian groups are ways in which information can be disclosed. As we noted in the previous objective, be careful in what you say about certain projects in which you're involved. Although what you do may be unclassified, it may allow an agent to easily relate it to a more sensitive project. (REMEMBER: It takes only one person to speak a casual word or a few words to another person who is unaware of a situation and it may become common knowledge to all.)

Operational security results when you obey the security regulations and work directives that apply to your organization, when doing and documenting the maintenance, and when submitting requests and handling subsequent reports. Likewise, national security is protected when you treat all military business as official business when on and off the base. NEVER discuss sensitive information when using the telephone. Take care that you are not a weak link. The safeguarding of classified material and information is everyone's responsibility, as figure 3-6 indicates.

Exercises (028):

1. List the three types of security with which OPSEC relates.

2. State the one function that the four types of security provide.

3. List the operational phases in which OPSEC should be used.

4. Identify the three areas in which a communications organization is vulnerable to OPSEC weaknesses.

5. List some probable improper procedures that would lead to compromise.

40

CHAPTER 4

Fundamentals of Electricity

THE TELEPHONE equipment installation and repair specialist is concerned primarily with the installation, maintenance, and operation of telephone communications equipment. To do your job in these areas, it is necessary that you have an understanding of how the equipment operates. Since this equipment is electrical, we will explain that portion of electrical theory which is necessary for a clear understanding of the operating principles. Let's talk about electricity as it is used in telephony.

Our discussion will include electron theory of matter; electrical symbols; distribution of voltage, current, and resistance (including calculations in series resistive, parallel resistive, series-parallel resistive, and resistive bridge circuits); magnetism; sources of electrical energy; and electromagnetic devices. We conclude the chapter with information about trouble analysis.

4-1. Electron Theory of Matter

According to the electron theory, all physical materials are composed of atoms. Each atom consists of a positive nucleus with one or more negative charges (electrons). The electrons revolve around the nucleus.

029. Cite atomic and electrical laws.

Atomic Law. The atom of one element differs from the atom of another element because it has either fewer or more electrons around the nucleus. Thus, the charges of the two atoms are different. For an atom to be in balance, the quantity of positive charge on its nucleus must equal the quantity of negative charge provided by the electrons. An atom that loses an electron is unbalanced: it now has a greater positive charge since part of the negative charge has been lost. Such an atom (positively charged) has an attraction for negative electrons and for the negatively charged atoms. Conversely, an atom with more electrons than normal is also unbalanced. But, it is negatively charged and seeks a positively charged atom.

Electrical Law. In the resident course, you learned the basic electrical law that applies to this condition: unlike charges of electricity attract each other, and like charges of electricity repel each other.

A battery is a unit that is electrically charged. It is connected to a circuit consisting of predetermined electronic devices. Since the positive terminal of this battery has a shortage of electrons and the negative terminal has an excess number of electrons, electrons flow from the negative terminal through the circuit to the positive terminal. The number of electrons that pass through the circuit within a certain period of time is determined by the electronic devices and by the strength of the electrical charge at the source. You learned that this relationship is spoken of as Ohm's law. According to this law, the amount of electrons flowing in the circuit is, at any given time, determined by dividing the resistance into the voltage ($I = E/R$). This electric current is measured in amperes (milliamperes or microamperes).

Considering the atomic (chemical)/electrical relationship, remember that it's an atomic/electrical action that is useful in the telephone system. You learned that each telephone system includes a battery. A battery is a unit that produces electricity from a chemical action. Electrons flow in the electrolyte from the positive terminal to the negative terminal as a result of this chemical action. Corrosion, which results from chemical action, is harmful to telephone system components.

Exercises (029):

1. State the atomic law about the positively charged nucleus.

2. State the electrical law for unlike charges.

3. State the electrical law for like charges.

4. Write the Ohm's law formula for current.

4-2. Electrical Terms and Electrical Symbols Review

A technician in any career field that includes electrical equipment can speak fluently with others in the field and in allied fields. During their discussions, they use terms that are job related. The technician will use electrical symbols when presenting a circuit, for they simplify the presentation and permit a more rapid understanding of the circuit principles.

030. Identify electrical terms and circuit symbols.

We know that there are many terms which apply specificall to electrical circuit descriptions. It is not necessary, however, that we mention every term because many are familiar to all electrical systems workers, whether they work with automotive electrical systems, building electrical systems, radio systems, or telephone systems.

Electrical Terms. We are listing only a few terms which relate to sample telephone circuit diagram illustrations whi you can use when reviewing component connections and actions. You have seen these terms in the resident course study materials. Additional terms used in the communications field are to be found in the glossary.

Differential. The differential feature results because of a difference in quantities or quality. For instance, a differential relay operates or fails to operate because of the difference in current. Current in both windings prevents the relay from operating because of magnetic opposition. On the other hand, current in only one winding operates the relay.

Energized. Energized refers to a condition in which current is flowing in the device; thus, it is operating. To illustrate, when relay A in figure 4-1 is energized, it opens contacts 1T and 2 and makes contacts 3 and 4T. Yet, energized may not mean this in all circumstances because some descriptions specify energized as the condition in which the device has preoperational current; then an additional surge of current follows which operates the device.

Preparing a circuit. You will often find this expression used when the circuit activities of communications equipment are being described. It identifies an action within a circuit which has several open contacts, where one part of the circuit has just been closed. Now look at contacts 3 and 4T for relay B in figure 4-1. They close together when the B relay operates to prepare the operating circuit for relay FL1. Relay FL1 will operate only after relay A restores, following the operation of relay B, thereby closing contacts 1T and 2.

Ringing. Signaling is accomplished by using alternating current. But it is the usual practice to connect the ringing lead to a battery source, because this connection permits an associated relay to operate to cut off the ringing. A polarized relay or a slow-to-operate relay may do this. In addition, making the AC circuit a low-value current circuit while the DC circuit is developed to have a greater current flow would allow this cutoff operation. You will often see this connecting procedure referred to as superimposed ringing.

Electrical Symbols. Symbols which represent the various devices on electrical equipment schematic diagrams often differ. Figure 4-2 pictures some of the symbols with which

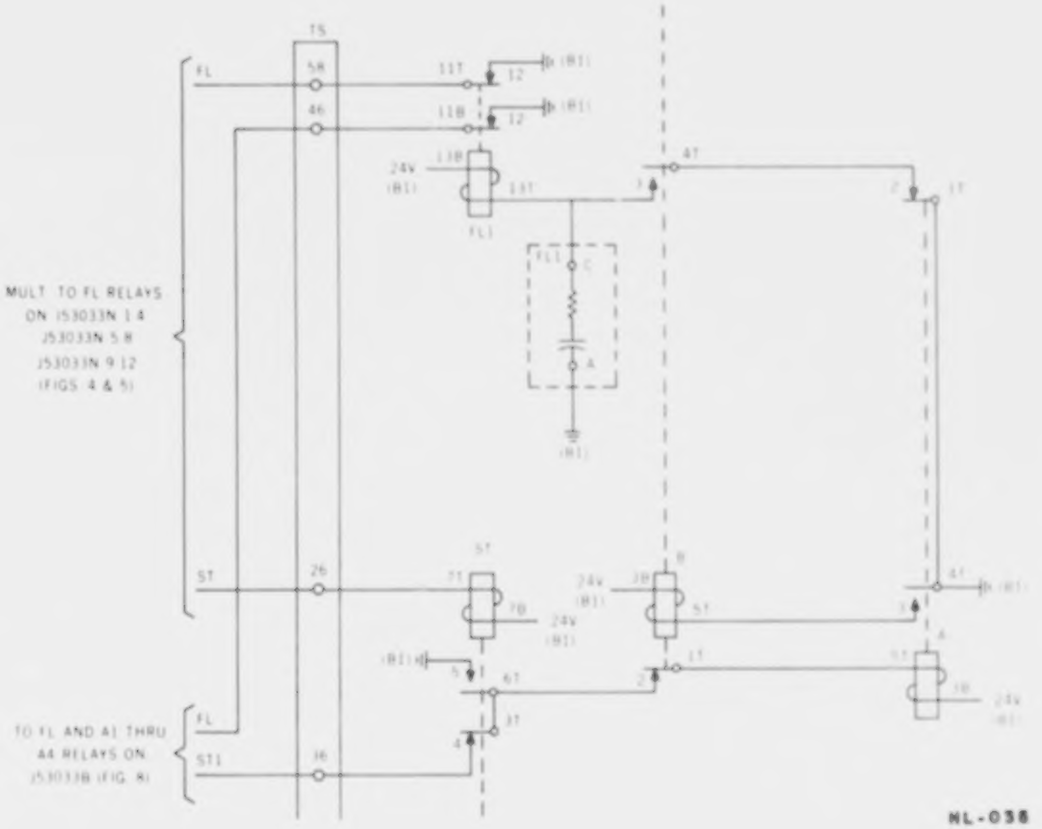


Figure 4-1. Example telephone system circuit.

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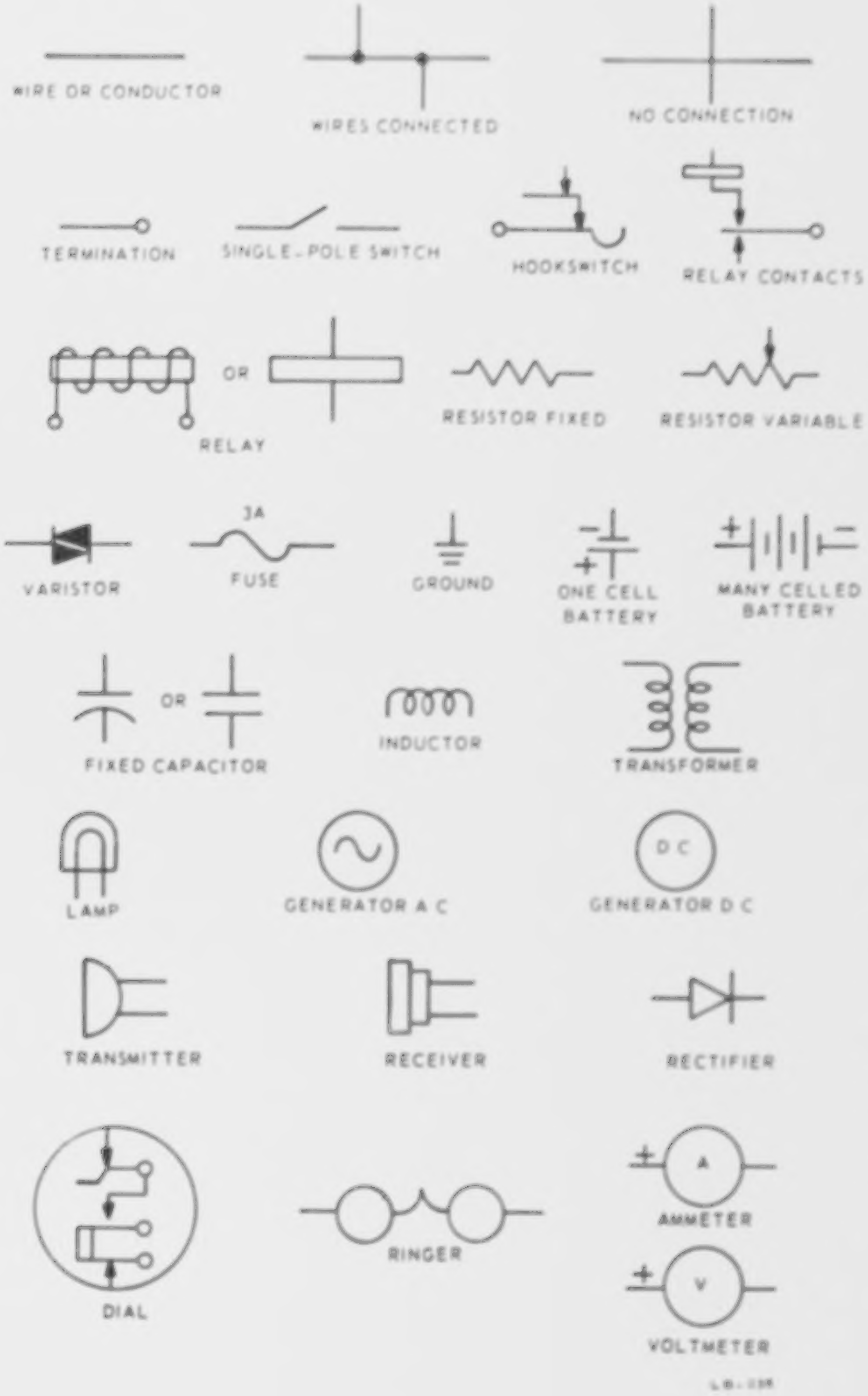
WIRE OR CONDUCTOR
WIRES CONNECTED
NO CONNECTION
TERMINATION
SINGLE-POLE SWITCH
HOOKSWITCH
RELAY CONTACTS
OR
RELAY
RESISTOR FIXED
RESISTOR VARIABLE
VARISTOR
3A
FUSE
GROUND
ONE CELL BATTERY
MANY CELLED BATTERY
OR
FIXED CAPACITOR
INDUCTOR
TRANSFORMER
LAMP
GENERATOR A C
D C
GENERATOR D C
TRANSMITTER
RECEIVER
RECTIFIER
DIAL
RINGER
A
AMMETER
V
VOLTMETER
LB-338

Figure 4-2. Representative electrical symbols.

you should be familiar. To illustrate, the straight line represents a wire which you traced many times in the resident course. Thinking of each symbol as a part of the circuit and understanding its function make circuit analysis easier. Consequently, equipment trouble can be located and repaired more rapidly. Let's now look at the symbo relationship of the circuit components in the schematic diagram of figure 4-1.

This figure shows the relationship of some devices in a circuit for one communications system. You will learn more about this circuit in Volume 4. On this figure you can see that the negative of the 24-volt battery (B1) is connected to the B terminal of the four relays (A, B, ST, and FL1). In addition, contacts 3 and 4T of relay B appear beside relay FL1. This appearance is not a true representation of their position because they are actually included within the framework of relay B and beside contacts 2 and 1T. It is not good practice to memorize schematic diagrams for circuits. This type of illustration can be misleading. Other circuit symbols for figure 4-1 are comparable to the symbols of figure 4-2; for example, straight lines for conductors, circles that represent terminals, and conductors that cross without making a connection. Remember, when you place various symbols together in a specific manner, you have an electrical diagram.

Exercises (030):

1. Give the term that indicates the condition of relay ST when ground potential is connected to terminal 26 of block TS (fig. 4-1).

2. Give the term used to describe the action of relay contacts 3 and 4T of relay B in text figure 4-1.

3. What voltage should you find at terminal 26 of the TS term strip (fig. 4-1)?

4. Name the two devices connected between terminals A and C within the dashed line block of text figure 4-1.

5. Using text figure 4-1, name the devices that provide the operating circuit for relay FL1.

4-2. Electrical Diagrams

We saw that figure 4-1 is a schematic diagram. You know that there are many diagrams that can be used to simplify circuit analysis. Consequently, you should not find it difficult to understand the theory and principles of a telephone circuit. Word descriptions are also used with the circuit diagrams to increase your understanding. Diagrams that we will describe are: schematic, wiring, block, and line and contact.

031. Using figures 4-1 through 4-5, identify circuits, circuit components, circuit functions, and circuit connections.

Schematic Diagram. This diagram (see fig. 4-1) is most oft used when explaining the circuit relationships because the circuits are easier to trace. The schematic allows emphasis of the important features of the circuit. Conventional symbols are used, but their position or placement does not necessarily correspond to the location of the actual part within the equipment circuit. Since schematics are not true pictures of an equipment circuit, learn the principles of operation of the devices of the circuit. This includes a knowledge of the current in the circuit, the voltage at the various components, and the power requirements. Effective understanding is made possible by breaking the complex circuits into a number of simple circuits. Frequently, certain small groups of parts form relatively simple units within the complex circuit. For example, a diagram of a complete telephone system can be broken down into a transmitter circuit, a receiver circuit, a ringing circuit, relay circuits, and several other smaller circuits. Learn to recognize these units and relate them to others. Each unit should be understood or thought of in terms of its function in the circuit. Also, try to visualize the actual unit position in relation to its position in the schematic.

The schematic diagram of figure 4-1 can be broken down into the START FLASHING circuit and LAMP FLASHING circuit Relays ST, B, A, and FL1 start the equipment LINE lamp flashing. The FL1 timing circuit (consisting of the resistor and capacitor between terminals A and C) control the length of time that the lamp flashes.

Wiring Diagram. This diagram illustrates the actual position and connection for each piece of equipment. Because of the emphasis on the connection of cables and terminal wiring, it is not readily used when you are trying to understand the operation of a circuit. Figure 4-3 may be considered a partial wiring diagram because it shows the wiring connections between the HOLD, PICKUP, and CUTOFF keys for a key telephone set. Accordingly, one contact for the HOLD key is strapped directly to a contact for each of the PICKUP keys.

Block Diagram. Figure 4-4 is a sample block diagram showing the essential elements of a telephone system. The relationship of the elements to each other is indicated by appropriate connecting lines in a block diagram. The direction or sequence of operation is often indicated by arrows. To illustrate, the example diagram shows one 1-way voice circuit where only the operator at position 1 in the OPERATIONS VAN can actuate the circuit. It also shows that two 1-way voice circuits are provided where people at both the OPERATIONS VAN and CONTROL TOWER can activate the telephone equipment which completes the call.

Line and Contact Diagram. The line and contact diagram is often called a drawing. This illustration shows an electric circuit and its connections through the use of lines

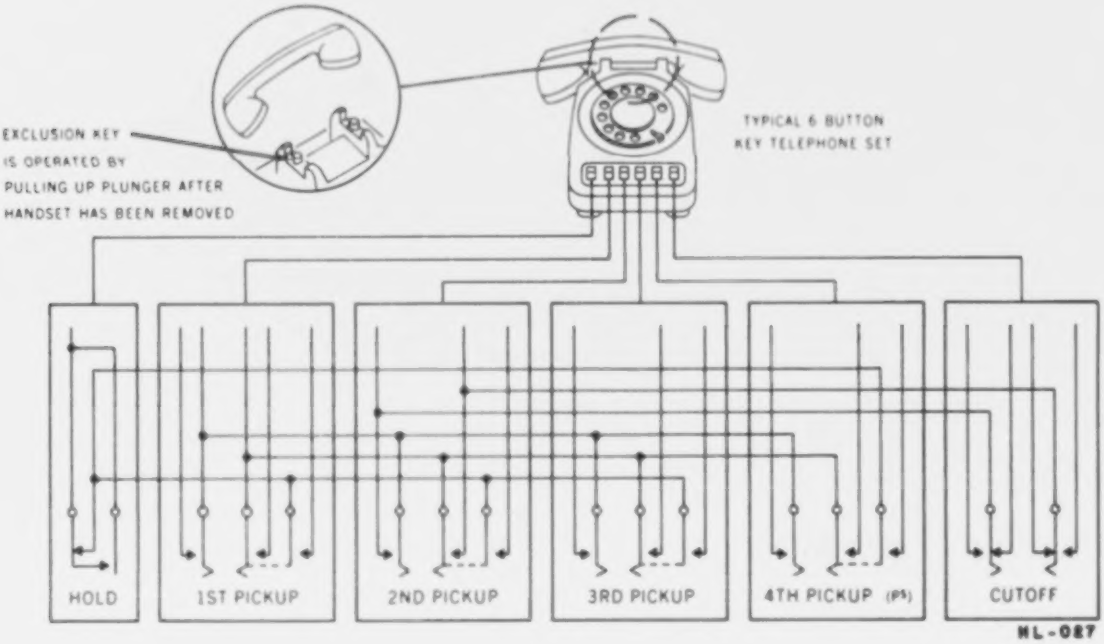

Figure 4-3. Typical key telephone set pushbutton and switch arrangement.

and symbols. Line and contact diagrams usually contain only one simple circuit, which starts at the power source and terminates at a ground, or vice versa. Figure 4-5 is such a circuit. In it you can see that the power source is represented with a negative 24 volts and a ground symbol. You should remember from your resident training that the X in the line drawing indicates that the device which it represents is operated. For example, the B–1 above the X in the line drawing of figure 4-5 identifies an operated relay in the J53033B equipment. Since this relay has operated, contact 12 is operated. As a result, relay A in the J53033M equipment operates. The operating circuit for relay A also includes nonoperated contacts 3 (relay A1), 3T–4 (relay ST) and 1T–2 (relay B). In addition, two terminals (36 and 38) and the ST1 lead are in the circuit.

Although we have seen and considered only a few sample circuit diagrams, you can use the same or similar methods for analyzing and explaining circuits and operating procedures for any telephone system because all electrical circuits have a voltage, resistance, and current relationship.

Exercises (031):

1. Give the battery number that provides −24 volts to the relays of the LAMP FLASHING circuit illustrated in figure 4-1.
2. Identify the PICKUP key that has its contacts strapped to the CUTOFF key contacts (illustrated in text fig. 4-3).
3. List the functions of the four circuits shown between the OPERATIONS VAN and the POWER VAN in text figure 4-4.
4. Using figure 4-4, specify the circuit that connects the wall telephone at the control tower to the power van equipment.
5. Using figure 4-4, name the circuits that serve the ground control intercept station.
6. Use figure 4-5 to identify the conductor that connects the J53033M and J53033B equipment together.

4-4. Voltage, Resistance, and Current Relationship in Electrical Circuits

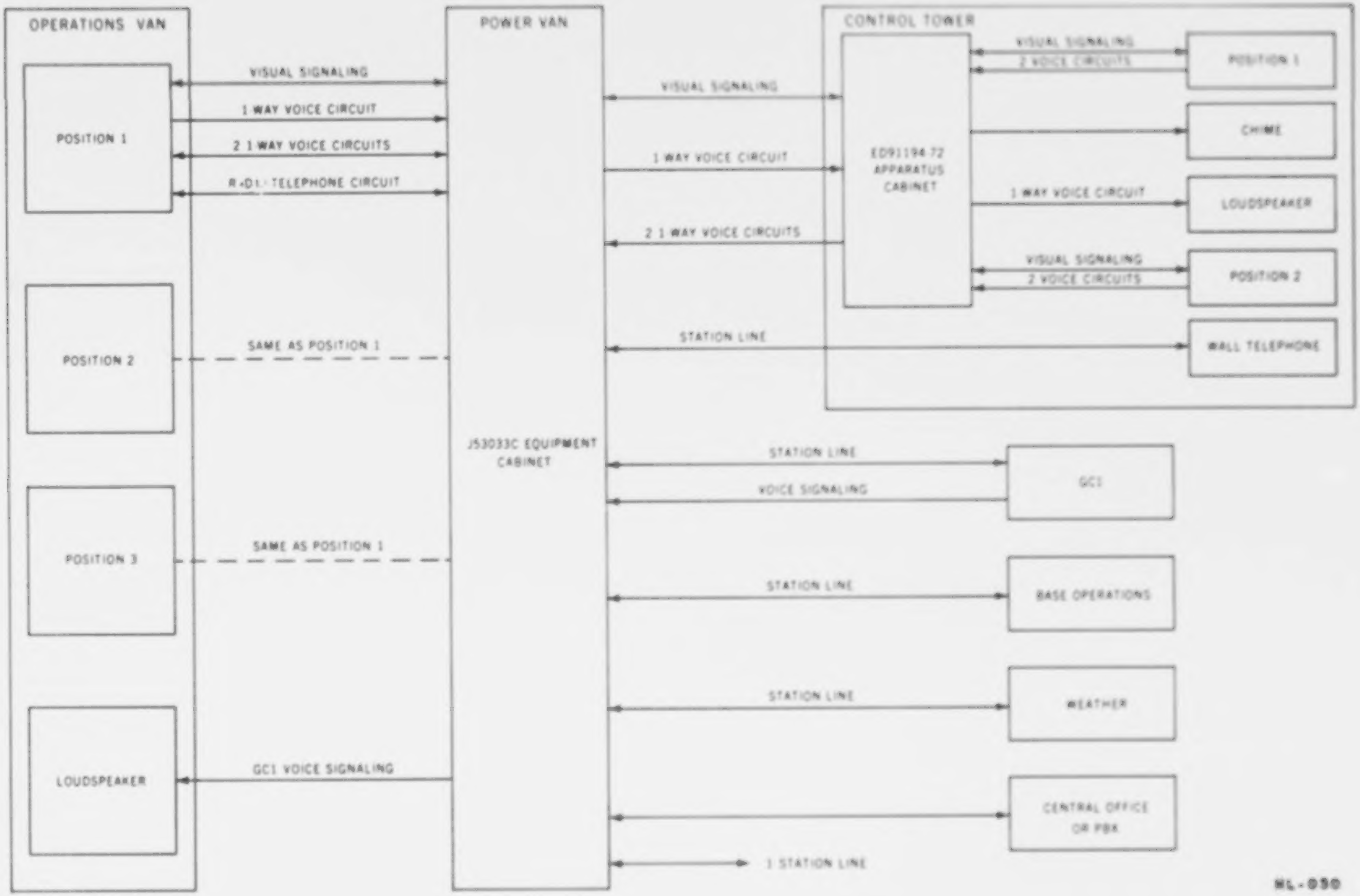
OPERATIONS VAN
POSITION 1
VISUAL SIGNALING
1 WAY VOICE CIRCUIT
2 1 WAY VOICE CIRCUITS
R-D1- TELEPHONE CIRCUIT
POSITION 2
SAME AS POSITION 1
POSITION 3
SAME AS POSITION 1
LOUDSPEAKER
GC1 VOICE SIGNALING
POWER VAN
J53033C EQUIPMENT CABINET
VISUAL SIGNALING
1 WAY VOICE CIRCUIT
2 1 WAY VOICE CIRCUITS
STATION LINE
CONTROL TOWER
ED91194-72 APPARATUS CABINET
VISUAL SIGNALING
2 VOICE CIRCUITS
POSITION 1
CHIME
1 WAY VOICE CIRCUIT
LOUDSPEAKER
VISUAL SIGNALING
2 VOICE CIRCUITS
POSITION 2
WALL TELEPHONE
STATION LINE
VOICE SIGNALING
GCI
STATION LINE
BASE OPERATIONS
STATION LINE
WEATHER
CENTRAL OFFICE OR PBX
1 STATION LINE
HL-030

Figure 4-4. Block diagram of 302 switching unit

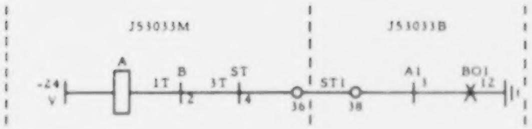

Figure 4-5. Sample line and contact drawing for a key system circuit.

We know that electric current is associated with voltage and resistance. These three factors are to be found in direct-current, alternating-current, and every other electrical circuit.

032. Using figures given, calculate the direct current, voltage, and resistance values for sample problems.

This section emphasizes the importance of using electrical circuit principles. Briefly, these principles include the following:

a. Ohm's law can be applied to any part of a circuit or to the complete circuit when two factors are known.
b. Current is the same in each part of a series circuit.
c. Voltage at each parallel branch is equal.
d. Total voltage is equal to the sum of the drops in series circuits.

Direct-Current Circuit Analysis. Let us look again at figure 4-1 and assume some resistance values for the purpose of analyzing this circuit.

Assuming that relay B has 400 ohms resistance, we can determine the current that is required to operate this relay. You should recall that a method used for making this determination is called Ohm's law. We know that according to this law, the resistance is divided into the voltage ($I = E/R$ or $I = 24/400$). As a result, the total current for our simple circuit is .060 ampere, or 60 milliamperes when contacts 3 and 4T of relay A are made (relay A is operated). Our analysis shows that the operation of relay B also completes the circuit to relay FL1. What, then, would a milliammeter register if placed between contacts 3 and 4T of relay B?

We immediately recognize that it is impossible to determine the current for relay FL1 while using Ohm's law because no resistance is shown for it. Again, we could assume a resistance to practice using this law. This is unnecessary since you used it with relay B, and we will use it again in this chapter. We want you to recall that by placing the milliammeter leads against contacts 3 and 4T, you have placed it in series with the circuit. This is a rule which you should remember. Likewise, you should place the meter controls so that the meter is prepared to read high value current, thus protecting the meter from damage.

The operated B relay also opens the operating circuit for relay A. Now, we realize that our previous statement in the above paragraph was not totally correct. Operated relay B moved contacts 3 and 4T together, but the operating circuit for relay FL1 was not really complete yet because contacts 1T and 2 of relay A are open until relay A is released. Consequently, you may consider relays B and FL1 as being parallel operated relays at the moment that relay A is released.

What are some of the rules that you learned about parallel devices in electrical circuits? The voltage across each device is the same and the current from the power source splits through the branches. This current is determined by the branch resistance and the total voltage. Furthermore, the total resistance in a parallel circuit is less than the smallest branch resistance. Figure 4-6 will help us review these rules. For instance, the 12-ohm resistor has only 2 amperes of current, whereas the smaller (8 ohms) resistor has 3 amperes.

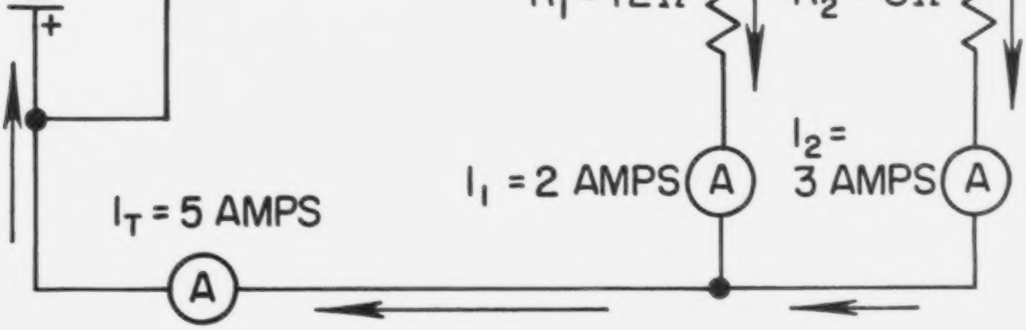

Figure 4-6. Sample electrical circuit.

Multiplying the current in each branch by its resistance reveals that the voltage for each branch is 24 volts. To determine the total resistance for the circuit, see Ohm's law (R = E/I). As a result, the circuit resistance is 4.8 ohms.

Exercises (032):

1. Consider relay FL1 of text figure 4-1 as having a resistance of 600 ohms. What current would be in the relay when the operating circuit is complete?

2. Assuming that the current for the operating circuit of relay A in test figure 4-1 is .015 amperes, what would be its resistance?

3. What voltage should be registered by the voltmeter of the circuit in figure 4-6?

033. Using figures 4-7 through 4-9, solve problems for typical balanced resistive bridge circuits.

The bridge circuit is basically a parallel arrangement with a load of some sort connected between its branches. It is used in numerous applications in the communications field, especially in test equipment and power supplies. Bridge circuits may be constructed with either fixed or adjustable components and may contain such items as fixed resistors, variable resistors, diodes, capacitors, or inductors. In addition, the bridge circuit may be regarded as balanced or unbalanced. We will first consider a balanced bridge.

Balanced Bridge Circuit. In figure 4-7 you can see a parallel circuit consisting of two branches, each having two series connected resistors. Current flows in each branch and the two currents join to return to the battery. Near the center of each branch are two terminals, identified as A and B. Figure 4-8 is the same circuit as figure 4-7, but the illustration is drawn to form the characteristic diamond shape of a bridge circuit. For the bridge to be complete, however, there must be a load of some kind connected between terminals A and B. This may be a resistor, coil, or any one of numerous electrical devices. In most test equipment, it is normal for the device in this position to be a galvanometer. The galvanometer shows the current that is flowing when the bridge is unbalanced.

What makes this bridge circuit balanced? The answer to this question is that a balanced bridge circuit has no potential difference between terminals A and B. A second question is: How do you determine when a bridge circuit is balanced? Two common methods are the ratio relation method and the Ohm's law method. We will first show the ratio relation method. In figure 4-9 the bridge circuit has had arrows added that show the relation between the four resistors. Note that R_2 is twice as large as R_1, and R_4 is twice as large as R_3. Therefore, we can see the relationship that follows:

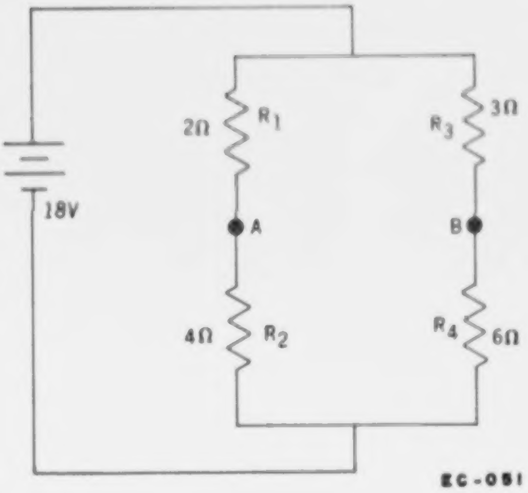

Figure 4-7. Series-parallel bridge circuit.

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad \text{or} \quad \frac{2}{4} = \frac{3}{6} = \frac{1}{2}$$

From the above problem, it can be seen that the two branches have an equal ratio. Furthermore, the ratio for resistors R_1 and R_3 is equal to the ratio for resistors R_2 and R_4 (2/3 = 4/6). Thus, the circuit is in balance.

To check the circuit by Ohm's law, we must determine the potential difference, if any, between terminals A and B. To do this, follow these four steps:

(1) Determine the resistance of branches A and B.
(2) Determine the current for branches A and B.
(3) Calculate the voltage for terminals A and B.
(4) Find the potential difference between terminals A and B.

Since the resistors in each branch of our bridge circuit are in series, we can add them to get the total resistance of that branch. To illustrate: 2 ohms plus 4 ohms in the A-terminal branch results in 6 ohms total. The B-terminal branch has 9 ohms. The voltage at each branch is equal to the applied voltage (18 volts). Now, we have the voltage and resistance; hence, we can solve for the current in each branch. Using I = E/R, we find the current to be 3 amperes in branch A and 2 amperes in branch B.

Return to figure 4-8 and picture R_1 as having 3 amperes and R_3 as having 2 amperes. Again, we have two factors for each resistor. Thus, we can get the voltage at those resistors by using Ohm's law. R_1 has a voltage drop of 6 volts and R_3 has a voltage drop of 6 volts. The same procedures are used to get the voltage at resistors R_2 and R_4.

Now compare the voltage at terminal A to the voltage at terminal B. Since both terminals are 6 volts negative in respect to positive battery, it is evident that the circuit is balanced. Of course, you can also consider the two terminals 12 volts positive with respect to negative battery. Again, this means that the circuit is balanced because there is no potential difference between terminals A and B. If a

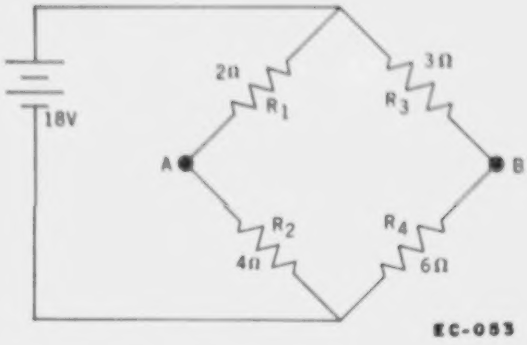

Figure 4-8. Basic bridge circuit.

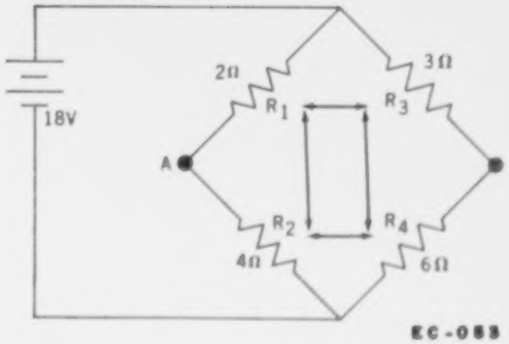

Figure 4-9. Relation between bridge resistors.

galvanometer is placed between terminals A and B, there will be no current flow through the meter.

Exercises (033):

1. Give the ratio for the listed resistors:
   R_1 = 1,000 ohms.
   R_2 = 10,000 ohms.
   R_3 = 500 ohms.
   R_4 = 5,000 ohms.

2. Using the resistance values R_1 = 100 ohms, R_2 = 50 ohms, R_3 = 150 ohms, and R_4 = 75 ohms for figure 4-8, determine the potential at points A and B.

034. Using figures 4-10 through 4-13 as needed, solve circuit values for an example unbalanced bridge.

Unbalanced Bridge Circuit. The unbalanced bridge circuit has a potential difference between terminals A and B. Therefore, current will flow in a galvanometer when connected between A and B. To solve for circuit values in an unbalanced bridge, use the methods described with the balanc bridge. Take the bridge of figure 4-10 as an illustration. Use the Ohm's law method and follow the four steps listed above, as follows:

Step 1 (resistance of branches):

$R_1 + R_2$ = 3 ohms + 12 ohms = 15 ohms
$R_3 + R_4$ = 6 ohms + 6 ohms = 12 ohms

Step 2 (current through branches):

$$I = E/R_A I = \frac{18}{15} = 1.2 \text{ amperes}$$

$$I = E/R_B I = \frac{18}{12} = 1.5 \text{ amperes}$$

Step 3 (voltage at points A and B, when compared to negative battery terminal):

E_A = IR E = 1.2 × 3 ohms = 3.6 volts
E_B = IR E = 1.5 amperes × 6 ohms = 9 volts

Step 4 (potential difference between terminals A and B):

$E_B = E_A = 9 - 5.4$ volts

As you can see from the above calculations, point B in figure 4-10 is 9 volts positive with respect to the negative battery terminal. Point A is only 3.6 volts positive with respect to the same terminal. Comparing point A to point B, we see that B is 5.4 volts positive with respect to the former. This difference in potential permits current to flow from A to B whenever a load is connected between the two terminals. Of course, the current is determined by the size of resistance in the load and the potential difference of the terminals.

Adding a galvanometer to the circuit changes the total resistance. This in turn changes the current in the branch resistors. As a result, the voltage is changed for these resistors. To illustrate, assume that the resistance through a galvanometer is 0. A conductor with 0 ohms placed between terminals A and B results in making a new circuit. Compare

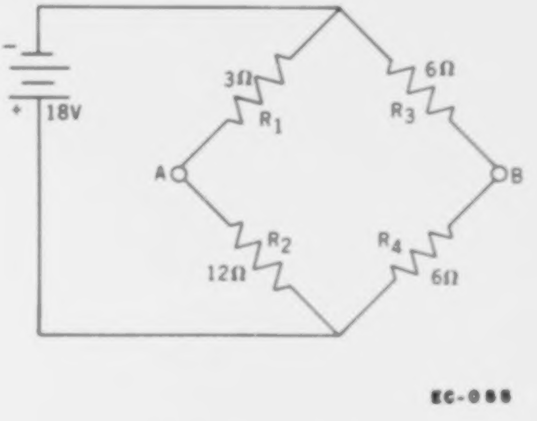

Figure 4-10. Unbalanced bridge circuit.

figures 4-10 and 4-11 and note the difference This short circuit has formed two parallel circuits. Also, the two parallel circuits are in series with the 18-volt power source. The following solutions show the new circuit values:

Step 1 (resistance of branches):

$$\frac{R_1 \times R_3}{R_1 + R_3} = \frac{3 \times 6}{3 + 6} = \frac{18}{9} = 2 \text{ ohms}$$

$$\frac{R_2 \times R_4}{R_2 + R_4} = \frac{12 \times 6}{12 + 6} = \frac{72}{18} = 4 \text{ ohms}$$

Step 2 (total resistance of branches):

$B_1 + B_2 = 2$ ohms $+ 4$ ohms $= 6$ ohms

Step 3 (total current):

$I = E/R \quad I = \frac{18}{6} \quad I = 3$ amperes

Step 4 (voltage at each branch):

$E = IR$
$E = 3 \times 2$ ohms $=$ 6 volts (circuit 2)
$E = 3 \times 4$ ohms $=$ 12 volts (circuit 2)

Step 5 (current in each resistor):

$I = E/R$

$I = \frac{6}{3} = 2$ amperes (R_1)

$I = \frac{6}{6} = 1$ ampere (R_3)

$I = \frac{12}{12} = 1$ ampere (R_2)

$I = \frac{12}{6} = 2$ amperes (R_4)

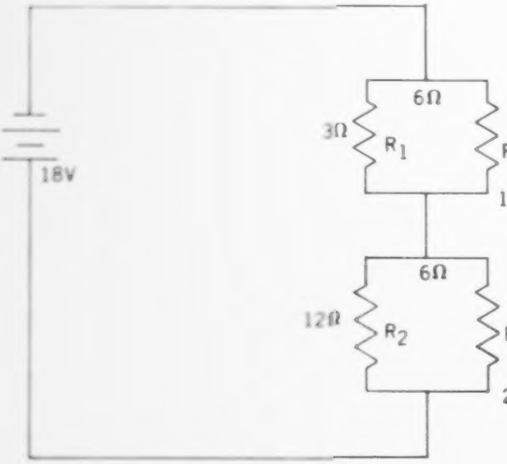

Figure 4-11. Two parallel circuits in series.

These new values, with a galvanometer between the terminals, are illustrated in figure 4-12. From this illustration, note that 2 amperes flow through R_1; yet only 1 ampere is shown for resistor R_2. In the same manner, resistor R_4 has 2 amperes while R_3 has only 1 ampere. It is evident, then, that 1 ampere must flow through the galvanometer (from point A to point B).

The solutions and description of the preceding paragraphs reveal that loading a bridge circuit with a galvanometer changes the current and voltage from that to be noted when the circuit is not loaded. This effect is true whether the load is low or high resistance.

We mentioned earlier that bridge circuits could contain variable components. Figure 4-13 shows a bridge circuit that contains a variable resistor. This resistor is used to balance an unbalanced bridge. When current is noted in the galvanometer of the bridge circuit, the control of the variable resistor is rotated until the current ceases in the galvanometer. Look again at figure 4-13 and determine the resistance required for R_3 when balancing the bridge. (NOTE: The slider reduces the resistance by short-circuiting resistance windings.)

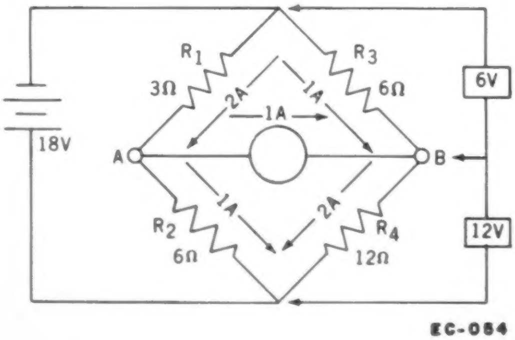

Figure 4-12. Galvanometer connected across bridge circuit.

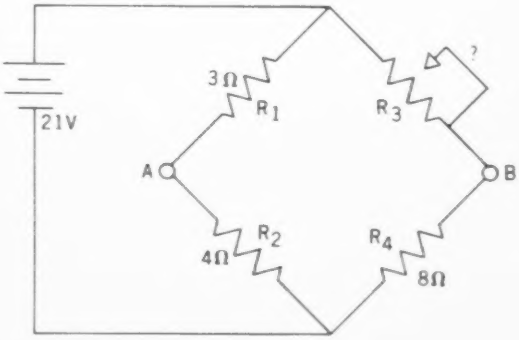

Figure 4-13. Bridge circuit with variable resistor.

The answer to this problem can be solved by the ratio method. By substituting X for the unknown resistance, we can solve the problem by using the ratio formula:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

thus

$$\frac{3 \text{ ohms}}{4 \text{ ohms}} = \frac{X}{8 \text{ ohms}}$$

therefore

$$4X = 3 \text{ ohms times } 8 \text{ ohms}$$
$$4X = 24 \text{ ohms}$$
$$X = 6 \text{ ohms } (R_3)$$

We can see now that R_3 must be reduced to 6 ohms to balance the bridge. Any other resistance, above or below 6 ohms, causes a potential difference between terminals A and B. This potential difference is indicative of an unbalanced bridge.

Exercises 034):

1. Use the resistors $R_1 = 12$ ohms and $R_3 = 36$ ohms with the circuit of figure 4-11 and determine the resistance for the parallel circuit consisting of these two resistors.

2. If the battery for the circuit of text figure 4-11 were 12 volts, what would be the total current of the circuit?

3. If the battery for the circuit of text figure 4-11 were 12 volts, what would the voltage at R_4 be?

035. State characteristics of AC current operating in primary and secondary circuits.

Alternating Current Circuit Analysis. Figure 4-14 illustrates a partial schematic diagram of a ringer. This ringer is equipped with several coils which enable the ringer to work when alternating curre passes through them. How is this action possible? The information in the following paragraphs provides the answer to this question.

Magnetic effects. One effect of current in a circuit is the creation of a magnetic field. Under certain conditions, current also produces light and heat. The effects that result from electron movement are basic to the operation of the telephone system. A telephone system uses relays which opera because of a magnetic field. It has alarms which also operate because of magnetic effects. The alarms are noticed because of lamps which operate as a result of current heating effects. Lamps also are supervision devices on switchboards. Heat is necessary for keeping a system dry, yet is unwanted when it is excessive. Electron flow can produce a chemical action. Additional actions that result from magnetism are alternating current generation, self-induction, and mutual induction.

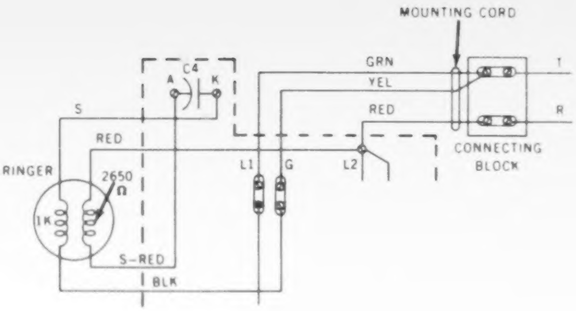

Figure 4-14. Partial telephone ringer circuit schematic diagram.

Mutual induction and self-induction are magnetic effects. Although magnetic effects may actually be inseparable, we will view them as individual elements.

You learned that the magnetic effects on the primary winding is called self-induction. The effects produced by the magnetic field of the primary moving into a secondary winding are referred to as mutual induction. In both windings, the induced voltage is in opposition to the inducing field's voltage.

Transformer action. A moving magnetic field provides the transformer action that develops voltage in the secondary winding(s). The magnetic field expands and thus moves through the primary winding and the secondary winding of the transformer. Keep in mind that mutual induction is achieved by magnetically linking the primary circuit of a unit to the secondary circuit. Such a linking device is called a transformer, an induction coil, or a repeating coil. The transformer can provide a greater or lesser voltage from the secondary than is applied to the primary, as well as an output voltage of the same value. (REMEMBER: The transformer output voltage is always AC whether the primary input is interrupted DC or AC.) The turns (loops) ratio between the primary and secondary determines the voltage relationship. You have learned that a transformer which has the most turns in the primary has an output voltage lower than its input voltage. Of course, a transformer can have a combination of step-up or step-down secondaries.

Because of the magnetic link between primary and secondary, it is logical that any change in one will affect the other. A decrease in the load (opposition) for the secondary can automatically increase current in the secondary and primary. This is a reason for a fuse becoming open in a primary circuit when a resistive device becomes shorted in electrical equipment.

Iron-core transformers are not normally used with radiofrequency circuits. The air-core transformer is used in conjunction with a capacitor or capacitors; and, as a result, they are made resonant (tuned) to a certain frequency or a band of frequencies. The type of response desired determines whether both the primary and secondary are tuned. In this equipment arrangement, the current of the secondary circuit has a negligible effect on the primary circuit. Changing the frequency or the capacitors changes the phase between the output and input voltage. (You have learned that an "in-phase condition" is where two or more sine waves pass through 0° to 180° simultaneously and reach peak values at the same time. An "out-of-phase" relationship is the reverse of in-phase.)

Impedance. The counter or back voltage of a self-inducing device, which has coils or windings, cannot be seen. However, its effects are very noticeable. Look at the coil of figure 4-15. This coil is shown with 50 ohms opposition. We know that hundreds of feet of wire are required to obtain just a few ohms of opposition; the resistance of wire is determined by the diameter of the wire and the wire type. Wire in the coil of our illustration, then, is not likely to provid the indicated opposition. The self-induction feature of the coil provides the impedance, the opposition for the circuit. The self-induction opposition of a coil is changed with AC frequency changes.

The opposition shown for the coil in figure 4-15 would be further increased if it contained an iron core. The iron core allows for a better transfer of magnetic flux between the conductor loops than does an air core coil. This is the reason for the increase in opposition. To illustrate, assume that the coil in our figure has 50 millihenries of inductance and that it is replaced with an iron core coil that has 1 henry of inductance. The opposition to the circuit current should increase to approximately 1,000 ohms.

Current generation. The demonstration shown in figure 4-16 is representative of those that you saw in the resident course. It reveals the three factors necessary for generating alternating current: a magnetic field, a looped conductor, and motion. You can see that the movement of the coil onto (fig. 4-16,B) and up from (fig. 4-16,C) the permanent magnet is reflected by the meter. The meter pointer moves first to the 5 at the right, then to the 5 at the left. The same principle is used in a generator. In the generator, the coil windings rotate through a permanent magnetic field.

The number of lines of magnetic force which are cut per second by the looped conductor determines the strength of the voltage induced in the conductor. There are a greater number of magnets and a larger number of conductors in generators than have been shown in figure 4-16. These additional conductors and magnetic poles result in an increase voltage and frequency for the generator's output over that which is developed in the demonstration. Remember that the same effects result if the magnet is moved and the coil is held immovable.

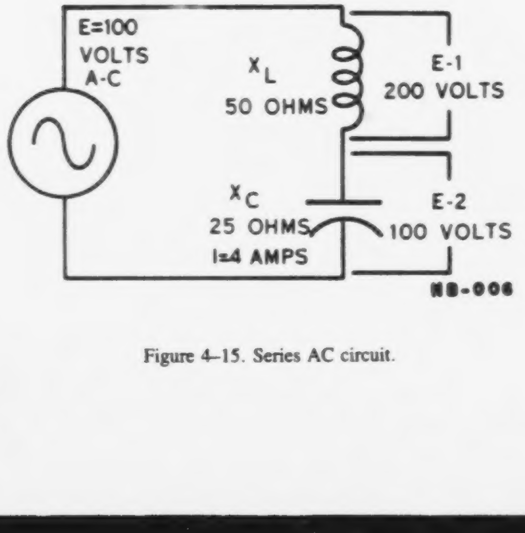

Figure 4–15. Series AC circuit.

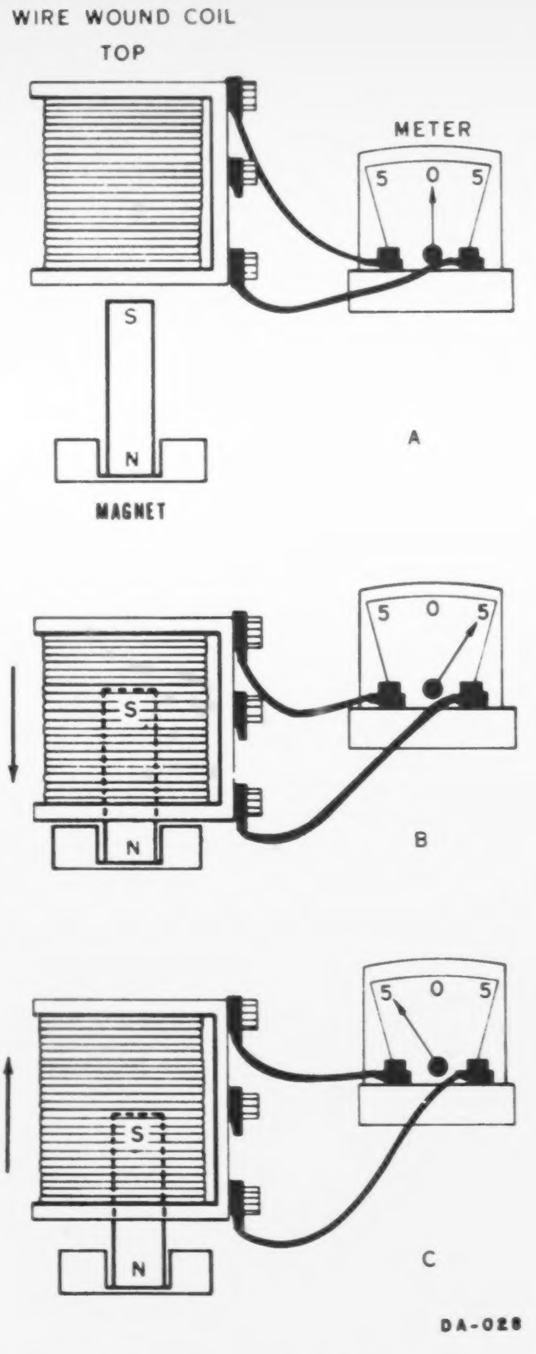

Figure 4–16. Generation of AC.

The major difference between AC and DC generators is their external connections. An AC generator has brushes and sliprings; whereas, a DC generator has brushes and a commutator. Figure 4-17 pictures two magnetic poles for a generator and the armature which rotates between them. The output voltage developed by this rotating armature is called a sine wave. The peak voltage is produced by conductors at the 90° and 270° positions of rotation. We are seldom concerned with these peak voltages, since the equipment normally operates with the effective value of AC. Each sine wave represents an AC cycle. The number of cycles provided per second results in the AC frequency.

NOTE: A frequency term that has been adopted in the electronic field is the word "hertz." Hertz has the same meaning as cycles per second, and it is abbreviated as HZ. By the same token, the term "kilohertz," abbreviated KHZ, has the same meaning as kilocycle.

Exercises (035):

1. List three additional actions that result from magnetism.
2. Define mutual induction.
3. How is mutual induction achieved?
4. If we decrease the load for the secondary circuit, what would be the effect on the primary circuit?
5. What are the three factors necessary for generating alternating current?
6. What type of external connections to AC generators have?

036. Distinguish between true and false statements concerning types of AC circuits and solutions to circuit problems.

It appears that the circuit of figure 4-14 has two unknown factors: (1) the applied voltage and (2) the current. A little consideration, though, should reveal that Air Force telephone systems use a ringing current from signaling. Generally this AC has a potential of 90 volts at 20 cycles per second. Thus, by knowing the applied voltage and the resistance, we can determine the circuit current using Ohm's law.

Resonance. Let us think about the circuit of figure 4-15 again. The current in the series circuit is 4 amperes and the opposition offered by the coil is 50 ohms. Using Ohm's law, you learn that the indicated voltage (200 ohms) is correct. You also should prove the values shown for the capacitor.

What else do you remember about the circuit of figure 4-15? Is it a resonant circuit? You should recall that the opposition of the inductor (X_L) must equal the opposition of the capacitor (X_C) when a circuit is resonant. This illustrated circuit does not show a resonant condition, since X_L is 50 ohms and X_C is 25 ohms. The frequency must be decreased to bring the two reactances to an equal value, since X_L decreases and X_C increases with this reduction. You also learned that the impedance of a resonant circuit is equal to the resistance, since X_L opposes X_C. In figure 4-15, the resistance would be slight at resonance because there is no resistor in the circuit. Consequently, with minimum opposition at the resonant frequency, the current is high. This illustrated figure also reveals another characteristic of an AC circuit with a series inductor and capacitor. The

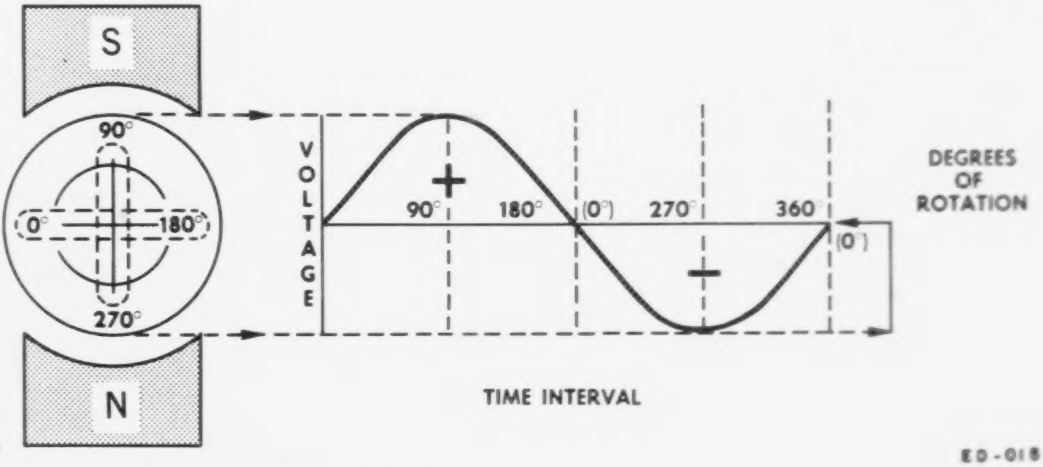

Figure 4–17. AC sine wave development.

voltage at each reactive device is high when compared to the input voltage.

A series-resonant circuit is used to filter out an undesired frequency from a circuit or as is often stated, "to pas the undesired frequency." It is effective because it appears as a short circuit to the resonant frequency but as high opposition to other frequencies.

Figure 4-18 illustrates a parallel arrangement of a capacitor and an induction coil. Since they are in parallel with the source of power, we know that each device has 100 volts applied to it. Thus, you can check the listed values with Ohm's law for AC to verify that they are correct. The total current for the circuit should restore to your memory that this type of circuit is characterized by having minimum current at resonance. Also, we can conclude that a circuit which has minimum current must have high impedance. The primary need in equipment with this type of circuit is voltage stability for one frequency and good discrimination against the off-resonance frequencies. Indeed, a parallel-resonant circuit is widely used in electronic circuits for restricting frequencies while passing another frequency or for passing a frequency and its band (closely related frequencies).

Exercises (036):

Mark a T for the true statements and an F for those that are false.

____ 1. The coils of the ringer in figure 4-14 are parallel connected.
____ 2. The circuit of figure 4-18 is resonant.
____ 3. Assuming 90 volts for the 1000-ohm ringer winding in text figure 4-14, the current is approximately 9 amperes.
____ 4. The current in the inductor of figure 4-15 is 4 amperes.
____ 5. The total opposition for the circuit of figure 4-18 is 200 ohms.

4-5. Principles of Trouble Analysis

Searching for trouble is part of your job. Thus, you should know the types of faults that plague telephone equipment, and you should understand the conditions that cause these faults.

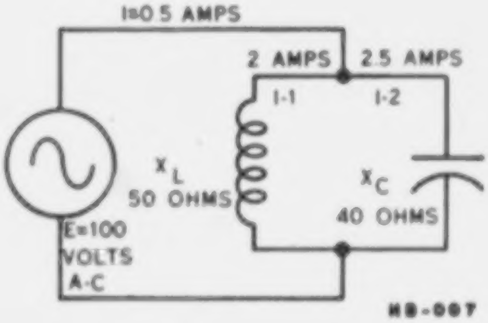

Figure 4-18. Parallel AC circuit.

037. Name common circuit troubles and list procedures for troubleshooting them.

Troubleshooting Procedures. Successful troubleshooting results from good procedures, accurate thinking, and practice. Troubleshooting requires you to think logically and use a sequence of basic steps. Study your telephone equipment so that you know the trouble symptoms and where to start looking for troubles when a symptom is noted.

Common Troubles. Once you have identified a trouble symptom, try to analyze the equipment and isolate the fault to a particular unit or circuit. An analysis, however, seldom determines a specific component within the unit as being open- or short-circuited. Your experiences have shown the meaning of open circuit and short circuit. An open circuit has no current because the circuit opposition is infinite. A shorted circuit has less than normal resistance and an increased current. If you need further review, their definitions are included in the glossary. You may see an intermittent (disappearing) open or short. This type of trouble is caused by a loose connection or a temporary moisture condition. Visual inspection may be the only method for finding the defect. Permanent troubles are generally found by analysis and testing, since they remain in the equipment.

Summarizing, then, a systematic troubleshooter observes the trouble symptom(s), inspects the equipment, analyzes the circuits, isolates the fault to a particular unit, and localiz the trouble by thinking and testing. By following the circuit while using a systematic process of elimination, you can usually locate the fault in a minimum of time. This procedure eliminates the good circuit parts in sequence.

Exercises (037):

1. What is the circuit condition following the "blowing of a fuse"?

2. Specify a telephone circuit fault that is often most noticeable during a thunderstorm.

3. Tell the three preliminary procedures during telephone system troubleshooting.

4. What subsequent procedures are used to localize the fault?

038. Relate sample trouble symptoms to defective circuit components.

Trouble Symptoms. One equipment trouble symptom is the failure of a lamp to light. In another circumstance, a trouble could light an equipment lamp. Also, we have noted that another trouble symptom is a blown fuse. Replacement of the fuse without knowing that the short circuit is corrected is not a proper procedure. You could burn out the second fuse. Therefore, you should open the equipment on/off switch and inspect the equipment. Look for blackened components, loose wires that are touching neighbor wires or terminals, and devices that have strong, strange odors.

Noise is also a circuit trouble symptom. An open filter capacitor and a shorted coil will cause noise because they reduce filtering for the power circuit. Since capacitor input filters are highly charged at the instant of "switch on," they are often more troublesome in electronic circuits than are coils.

Exercises (038):

1. Match typical trouble symptoms in column A with the device that caused it in column B. A device may be used more than once.

Column A	*Column B*
____ (1) Noise.	a. Open key.
____ (2) Dark lamp.	b. Blown fuse.
____ (3) Strong odor.	c. Loose wire.
____ (4) Burnt component.	d. Open capacitor.
____ (5) Glowing lamp.	e. Shorted coil.

039. Given example trouble symptoms, determine probable equipment troubles.

Trouble Analysis. When one parallel branch is opened, the total resistance of the circuit must increase. Figure 4-19 should help you to recall this. Before resistor R_3 opened, the total resistance equaled 15 ohms. With R_3 open, the total resistance equaled 18.75 ohms. If the circuit is opened between the power source and R_1, there would be no current flow. Thus, the condition is comparable to opening a switch in a series circuit. If one of the resistors (R_1, R_2, or R_3) is short-circuited, the total resistance then equals 0 ohms. If a short-circuited branch of a parallel circuit results in 0 ohms, what effect would a short across resistor R_2 in the circuit of text figure 4-6 have on the ammeter. Yes, the meter would show greater current. A normal circuit has a fuse and it will blow following a short circuit.

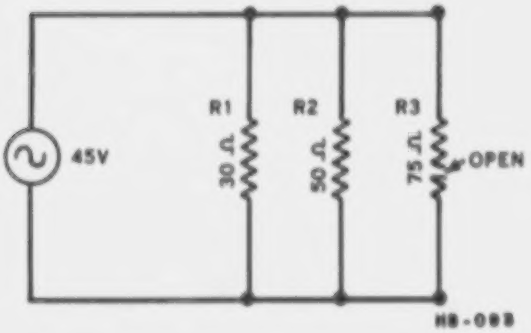

Figure 4-19. A parallel circuit with an open branch.

Let us think about another failure that may be applicable to your work. In this instance, you have depressed the keyset HOLD pushbutton, but the HOLD lamp has not lighted. We need to consider whether the trouble is just the lamp, or whether it is also the hold relay. If it is only an open lamp, the call circuit will be disconnected as normally required. You can determine this by listening to the receiver while talking to the party being held. Receiving no reply from this party indicates that the operated hold relay has progressed the actions to where a relay opens the transmitter circuit to this party. Replacement of the lamp should correct this open circuit.

We will now make an analysis of other possible circumstances. The symptom of trouble is that the HOLD lamp has operated following depression of the HOLD pushbutton, but the hold relay appears not to have operated. You determine if the relay has operated by talking and then listening for a reply from the party being held. If you hear a reply, you know that your transmitter circuit was not opened, possibly because of a hold relay failure. Surmising that the hold relay is failing, we should question whether the trouble can be an open, a short-circuit, or a maladjustment of the contact springs. The relay winding could be either short-circuited or open, resulting in its failure to operate. We know this to be true because an open winding prevents current; whereas, a short circuit bypasses the current around the winding. Maladjusted relay contacts are more likely to be trouble causes than are open or shorted circuits.

CAUTION: Never touch relay adjustments unless tests indicate that it is necessary to do so. Each system usually provides a test set with which you can determine the condition of the relay. A relay is not often checked individual because it is a part of a circuit. Your test of the circuit reveals the condition of the components.

You would use test equipment to check the resistance of the suspected components. However, you must isolate the parallel components to insure that your test is accurate.

Safety should always be a primary consideration when working with electronic circuits. You can be harmed by transient voltages. The manufacturer installs devices for the high voltages in a specific manner to protect the equipment and the personnel. You need not think about his or her reason for this arrangement, but you must think about the precautions to take when working with his or her equipment. For instance use a test lead and short circuit the input capacitor to insure that the high voltage is discharged.

If you are to fully understand a telephone system, it is necessary that you be familiar with its development and its operating principles. (Remember: The better you understand the fundamentals of electricity, the easier it will be for you to complete the following volumes in this course.)

people. Be sure that the people you talk with have a need to know and have been cleared to receive classified information.

Routine Functions. Routine activities often reveal significant intelligence information, thereby alerting unfriendly analysts to place more attention toward that command. For example, schedules posted on bulletin boards, releases to base or local newspapers, and comments made to friendly civilian groups are ways in which information can be disclosed. As we noted in the previous objective, be careful in what you say about certain projects in which you're involved. Although what you do may be unclassified, it may allow an agent to easily relate it to a more sensitive project. (REMEMBER: It takes only one person to speak a casual word or a few words to another person who is unaware of a situation and it may become common knowledge to all.)

Operational security results when you obey the security regulations and work directives that apply to your organization, when doing and documenting the maintenance, and when submitting requests and handling subsequent reports. Likewise, national security is protected when you treat all military business as official business when on and off the base. NEVER discuss sensitive information when using the telephone. Take care that you are not a weak link. The safeguarding of classified material and information is everyone's responsibility, as figure 3-6 indicates.

Exercises (028):

1. List the three types of security with which OPSEC relates.

2. State the one function that the four types of security provide.

3. List the operational phases in which OPSEC should be used.

4. Identify the three areas in which a communications organization is vulnerable to OPSEC weaknesses.

5. List some probable improper procedures that would lead to compromise.

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CHAPTER 4

Fundamentals of Electricity

THE TELEPHONE equipment installation and repair specialist is concerned primarily with the installation, maintenance, and operation of telephone communications equipment. To do your job in these areas, it is necessary that you have an understanding of how the equipment operates. Since this equipment is electrical, we will explain that portion of electrical theory which is necessary for a clear understanding of the operating principles. Let's talk about electricity as it is used in telephony.

Our discussion will include electron theory of matter; electrical symbols; distribution of voltage, current, and resistance (including calculations in series resistive, parallel resistive, series-parallel resistive, and resistive bridge circuits); magnetism; sources of electrical energy; and electromagnetic devices. We conclude the chapter with information about trouble analysis.

4-1. Electron Theory of Matter

According to the electron theory, all physical materials are composed of atoms. Each atom consists of a positive nucleus with one or more negative charges (electrons). The electrons revolve around the nucleus.

029. Cite atomic and electrical laws.

Atomic Law. The atom of one element differs from the atom of another element because it has either fewer or more electrons around the nucleus. Thus, the charges of the two atoms are different. For an atom to be in balance, the quantity of positive charge on its nucleus must equal the quantity of negative charge provided by the electrons. An atom that loses an electron is unbalanced: it now has a greater positive charge since part of the negative charge has been lost. Such an atom (positively charged) has an attraction for negative electrons and for the negatively charged atoms. Conversely, an atom with more electrons than normal is also unbalanced. But, it is negatively charged and seeks a positively charged atom.

Electrical Law. In the resident course, you learned the basic electrical law that applies to this condition: unlike charges of electricity attract each other, and like charges of electricity repel each other.

A battery is a unit that is electrically charged. It is connected to a circuit consisting of predetermined electronic devices. Since the positive terminal of this battery has a shortage of electrons and the negative terminal has an excess number of electrons, electrons flow from the negative terminal through the circuit to the positive terminal. The number of electrons that pass through the circuit within a certain period of time is determined by the electronic devices and by the strength of the electrical charge at the source. You learned that this relationship is spoken of as Ohm's law. According to this law, the amount of electrons flowing in the circuit is, at any given time, determined by dividing the resistance into the voltage ($I = E/R$). This electric current is measured in amperes (milliamperes or microamperes).

Considering the atomic (chemical)/electrical relationship, remember that it's an atomic/electrical action that is useful in the telephone system. You learned that each telephone system includes a battery. A battery is a unit that produces electricity from a chemical action. Electrons flow in the electrolyte from the positive terminal to the negative terminal as a result of this chemical action. Corrosion, which results from chemical action, is harmful to telephone system components.

Exercises (029):

1. State the atomic law about the positively charged nucleus.

2. State the electrical law for unlike charges.

3. State the electrical law for like charges.

4. Write the Ohm's law formula for current.

4-2. Electrical Terms and Electrical Symbols Review

A technician in any career field that includes electrical equipment can speak fluently with others in the field and in allied fields. During their discussions, they use terms that are job related. The technician will use electrical symbols when presenting a circuit, for they simplify the presentation and permit a more rapid understanding of the circuit principles.

030. Identify electrical terms and circuit symbols.

We know that there are many terms which apply specificall to electrical circuit descriptions. It is not necessary, however, that we mention every term because many are familiar to all electrical systems workers, whether they work with automotive electrical systems, building electrical systems, radio systems, or telephone systems.

Electrical Terms. We are listing only a few terms which relate to sample telephone circuit diagram illustrations whi you can use when reviewing component connections and actions. You have seen these terms in the resident course study materials. Additional terms used in the communications field are to be found in the glossary.

Differential. The differential feature results because of a difference in quantities or quality. For instance, a differential relay operates or fails to operate because of the difference in current. Current in both windings prevents the relay from operating because of magnetic opposition. On the other hand, current in only one winding operates the relay.

Energized. Energized refers to a condition in which current is flowing in the device; thus, it is operating. To illustrate, when relay A in figure 4-1 is energized, it opens contacts 1T and 2 and makes contacts 3 and 4T. Yet, energized may not mean this in all circumstances because some descriptions specify energized as the condition in which the device has preoperational current; then an additional surge of current follows which operates the device.

Preparing a circuit. You will often find this expression used when the circuit activities of communications equipment are being described. It identifies an action within a circuit which has several open contacts, where one part of the circuit has just been closed. Now look at contacts 3 and 4T for relay B in figure 4-1. They close together when the B relay operates to prepare the operating circuit for relay FL1. Relay FL1 will operate only after relay A restores, following the operation of relay B, thereby closing contacts 1T and 2.

Ringing. Signaling is accomplished by using alternating current. But it is the usual practice to connect the ringing lead to a battery source, because this connection permits an associated relay to operate to cut off the ringing. A polarized relay or a slow-to-operate relay may do this. In addition, making the AC circuit a low-value current circuit while the DC circuit is developed to have a greater current flow would allow this cutoff operation. You will often see this connecting procedure referred to as superimposed ringing.

Electrical Symbols. Symbols which represent the various devices on electrical equipment schematic diagrams often differ. Figure 4-2 pictures some of the symbols with which

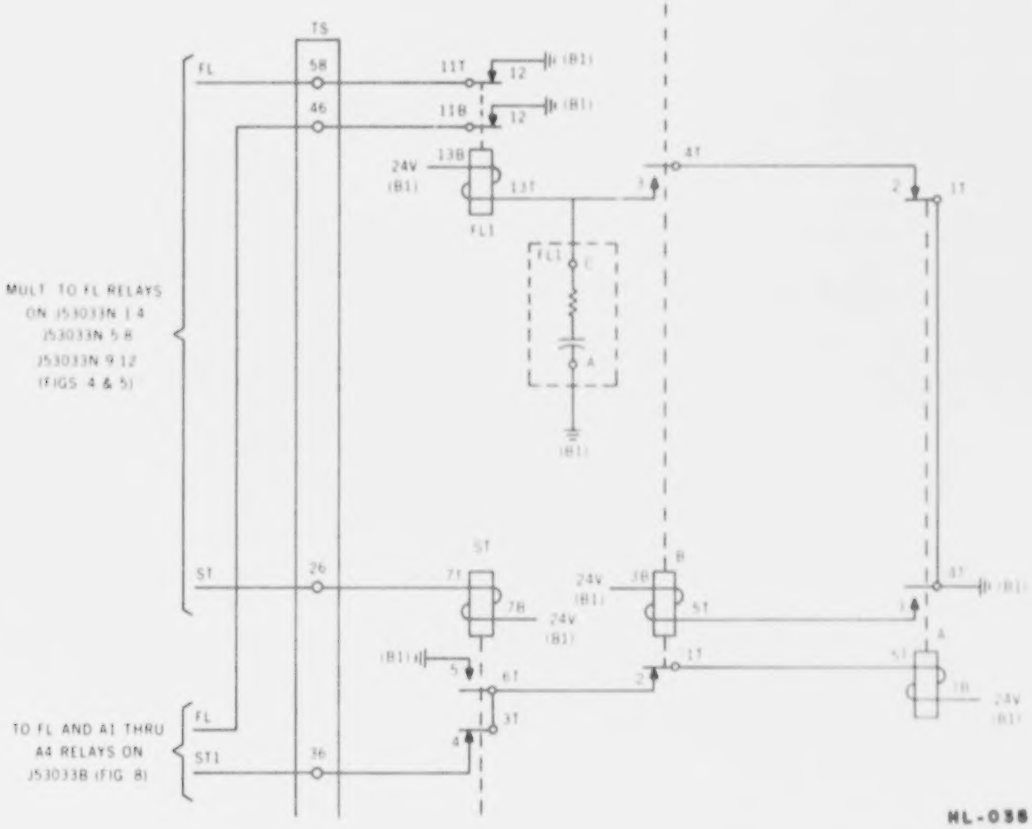

Figure 4–1. Example telephone system circuit.

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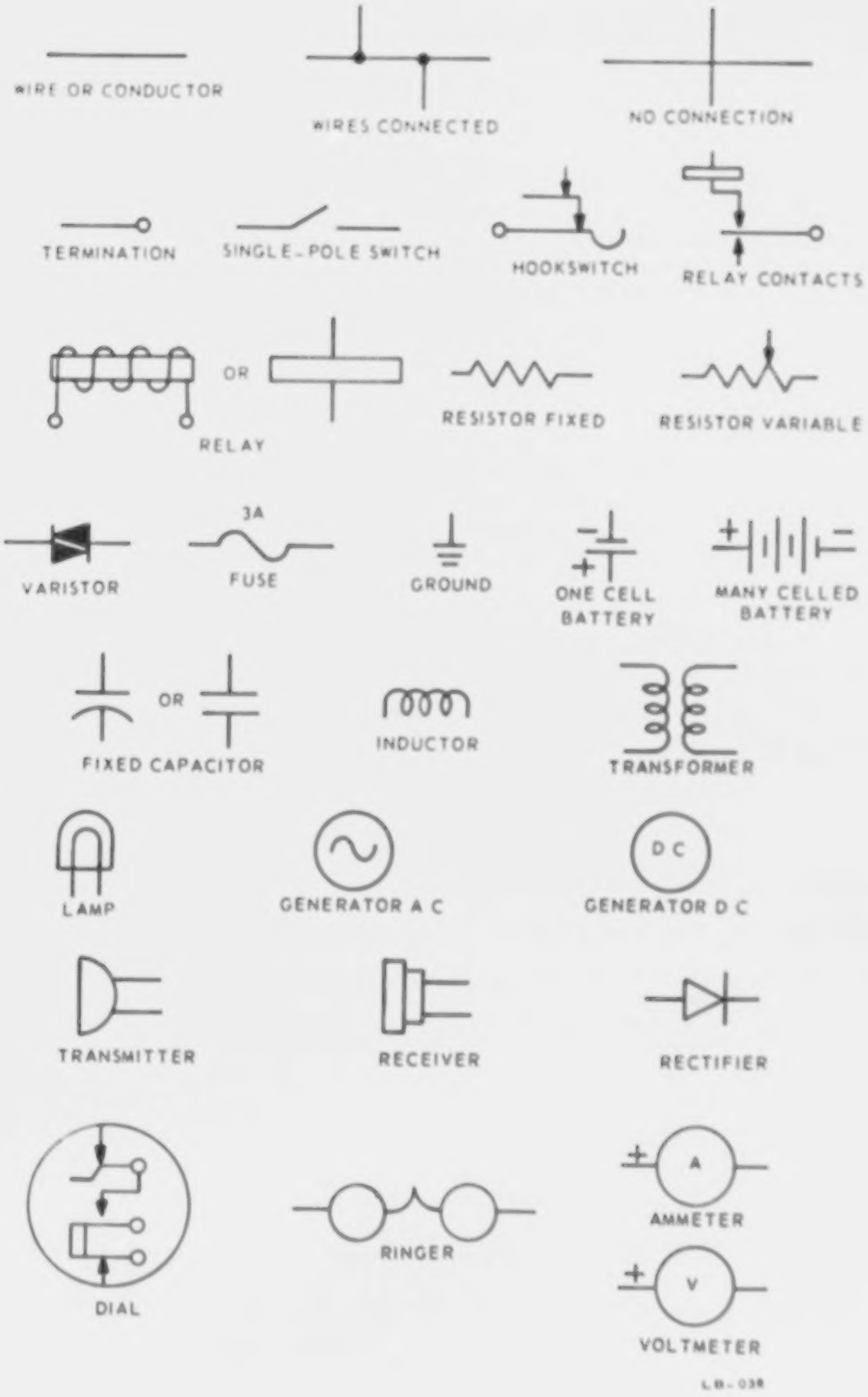
WIRE OR CONDUCTOR
WIRES CONNECTED
NO CONNECTION
TERMINATION
SINGLE-POLE SWITCH
HOOKSWITCH
RELAY CONTACTS
OR
RELAY
RESISTOR FIXED
RESISTOR VARIABLE
VARISTOR
3A
FUSE
GROUND
ONE CELL BATTERY
MANY CELLED BATTERY
OR
FIXED CAPACITOR
INDUCTOR
TRANSFORMER
LAMP
GENERATOR A C
D C
GENERATOR D C
TRANSMITTER
RECEIVER
RECTIFIER
DIAL
RINGER
A
AMMETER
V
VOLTMETER
LB-038

Figure 4–2. Representative electrical symbols.

you should be familiar. To illustrate, the straight line represents a wire which you traced many times in the resident course. Thinking of each symbol as a part of the circuit and understanding its function make circuit analysis easier. Consequently, equipment trouble can be located and repaired more rapidly. Let's now look at the symbo relationship of the circuit components in the schematic diagram of figure 4-1.

This figure shows the relationship of some devices in a circuit for one communications system. You will learn more about this circuit in Volume 4. On this figure you can see that the negative of the 24-volt battery (B1) is connected to the B terminal of the four relays (A, B, ST, and FL1). In addition, contacts 3 and 4T of relay B appear beside relay FL1. This appearance is not a true representation of their position because they are actually included within the framework of relay B and beside contacts 2 and 1T. It is not good practice to memorize schematic diagrams for circuits. This type of illustration can be misleading. Other circuit symbols for figure 4-1 are comparable to the symbols of figure 4-2; for example, straight lines for conductors, circles that represent terminals, and conductors that cross without making a connection. Remember, when you place various symbols together in a specific manner, you have an electrical diagram.

Exercises (030):

1. Give the term that indicates the condition of relay ST when ground potential is connected to terminal 26 of block TS (fig. 4-1).

2. Give the term used to describe the action of relay contacts 3 and 4T of relay B in text figure 4-1.

3. What voltage should you find at terminal 26 of the TS term strip (fig. 4-1)?

4. Name the two devices connected between terminals A and C within the dashed line block of text figure 4-1.

5. Using text figure 4-1, name the devices that provide the operating circuit for relay FL1.

4-3. Electrical Diagrams

We saw that figure 4-1 is a schematic diagram. You know that there are many diagrams that can be used to simplify circuit analysis. Consequently, you should not find it difficult to understand the theory and principles of a telephone circuit. Word descriptions are also used with the circuit diagrams to increase your understanding. Diagrams that we will describe are: schematic, wiring, block, and line and contact.

031. Using figures 4-1 through 4-5, identify circuits, circuit components, circuit functions, and circuit connections.

Schematic Diagram. This diagram (see fig. 4-1) is most oft used when explaining the circuit relationships because the circuits are easier to trace. The schematic allows emphasis of the important features of the circuit. Conventional symbols are used, but their position or placement does not necessarily correspond to the location of the actual part within the equipment circuit. Since schematics are not true pictures of an equipment circuit, learn the principles of operation of the devices of the circuit. This includes a knowledge of the current in the circuit, the voltage at the various components, and the power requirements. Effective understanding is made possible by breaking the complex circuits into a number of simple circuits. Frequently, certain small groups of parts form relatively simple units within the complex circuit. For example, a diagram of a complete telephone system can be broken down into a transmitter circuit, a receiver circuit, a ringing circuit, relay circuits, and several other smaller circuits. Learn to recognize these units and relate them to others. Each unit should be understood or thought of in terms of its function in the circuit. Also, try to visualize the actual unit position in relation to its position in the schematic.

The schematic diagram of figure 4-1 can be broken down into the START FLASHING circuit and LAMP FLASHING circuit Relays ST, B, A, and FL1 start the equipment LINE lamp flashing. The FL1 timing circuit (consisting of the resistor and capacitor between terminals A and C) control the length of time that the lamp flashes.

Wiring Diagram. This diagram illustrates the actual position and connection for each piece of equipment. Because of the emphasis on the connection of cables and terminal wiring, it is not readily used when you are trying to understand the operation of a circuit. Figure 4-3 may be considered a partial wiring diagram because it shows the wiring connections between the HOLD, PICKUP, and CUTOFF keys for a key telephone set. Accordingly, one contact for the HOLD key is strapped directly to a contact for each of the PICKUP keys.

Block Diagram. Figure 4-4 is a sample block diagram showing the essential elements of a telephone system. The relationship of the elements to each other is indicated by appropriate connecting lines in a block diagram. The direction or sequence of operation is often indicated by arrows. To illustrate, the example diagram shows one 1-way voice circuit where only the operator at position 1 in the OPERATIONS VAN can actuate the circuit. It also shows that two 1-way voice circuits are provided where people at both the OPERATIONS VAN and CONTROL TOWER can activate the telephone equipment which completes the call.

Line and Contact Diagram. The line and contact diagram is often called a drawing. This illustration shows an electric circuit and its connections through the use of lines

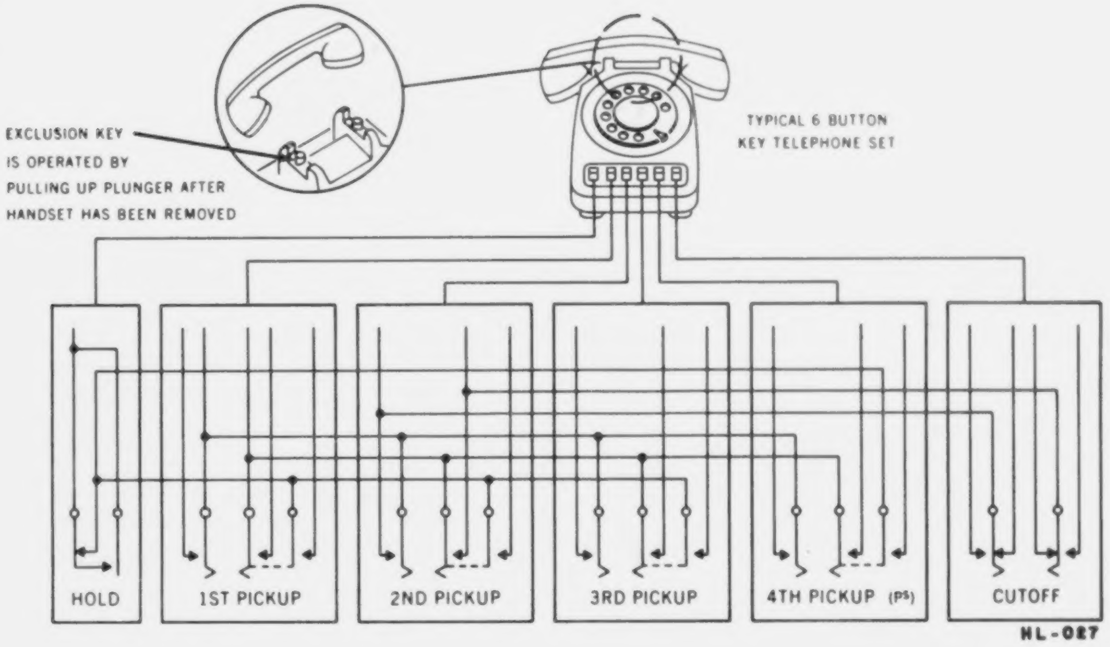

Figure 4–3. Typical key telephone set pushbutton and switch arrangement.

and symbols. Line and contact diagrams usually contain only one simple circuit, which starts at the power source and terminates at a ground, or vice versa. Figure 4-5 is such a circuit. In it you can see that the power source is represented with a negative 24 volts and a ground symbol. You should remember from your resident training that the X in the line drawing indicates that the device which it represents is operated. For example, the B–1 above the X in the line drawing of figure 4-5 identifies an operated relay in the J53033B equipment. Since this relay has operated, contact 12 is operated. As a result, relay A in the J53033M equipment operates. The operating circuit for relay A also includes nonoperated contacts 3 (relay A1), 3T–4 (relay ST) and 1T–2 (relay B). In addition, two terminals (36 and 38) and the ST1 lead are in the circuit.

Although we have seen and considered only a few sample circuit diagrams, you can use the same or similar methods for analyzing and explaining circuits and operating procedures for any telephone system because all electrical circuits have a voltage, resistance, and current relationship.

Exercises (031):

1. Give the battery number that provides −24 volts to the relays of the LAMP FLASHING circuit illustrated in figure 4-1.

2. Identify the PICKUP key that has its contacts strapped to the CUTOFF key contacts (illustrated in text fig. 4-3).

3. List the functions of the four circuits shown between the OPERATIONS VAN and the POWER VAN in text figure 4-4.

4. Using figure 4-4, specify the circuit that connects the wall telephone at the control tower to the power van equipment.

5. Using figure 4-4, name the circuits that serve the ground control intercept station.

6. Use figure 4-5 to identify the conductor that connects the J53033M and J53033B equipment together.

4-4. Voltage, Resistance, and Current Relationship in Electrical Circuits

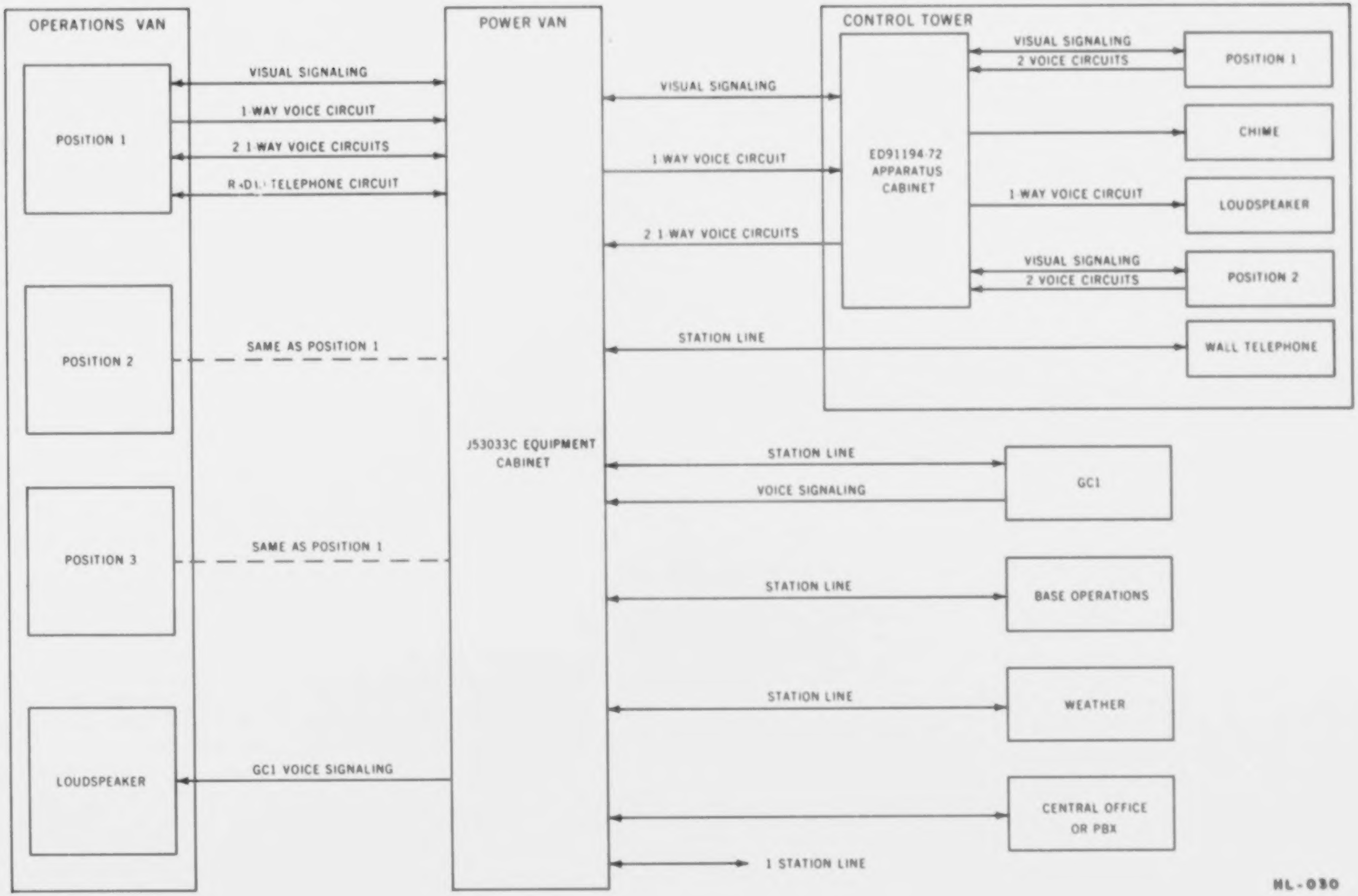
OPERATIONS VAN
POSITION 1
POSITION 2
POSITION 3
LOUDSPEAKER
VISUAL SIGNALING
1 WAY VOICE CIRCUIT
2 1 WAY VOICE CIRCUITS
RADIO TELEPHONE CIRCUIT
SAME AS POSITION 1
SAME AS POSITION 1
GC1 VOICE SIGNALING
POWER VAN
J53033C EQUIPMENT CABINET
VISUAL SIGNALING
1 WAY VOICE CIRCUIT
2 1 WAY VOICE CIRCUITS
STATION LINE
CONTROL TOWER
ED91194-72 APPARATUS CABINET
VISUAL SIGNALING
2 VOICE CIRCUITS
POSITION 1
CHIME
1 WAY VOICE CIRCUIT
LOUDSPEAKER
VISUAL SIGNALING
2 VOICE CIRCUITS
POSITION 2
WALL TELEPHONE
STATION LINE
VOICE SIGNALING
GC1
STATION LINE
BASE OPERATIONS
STATION LINE
WEATHER
CENTRAL OFFICE OR PBX
1 STATION LINE
HL-030

Figure 4-4. Block diagram of 302 switching unit.

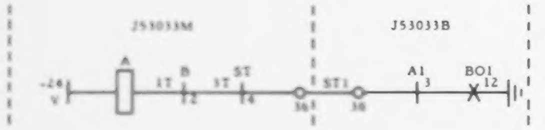

Figure 4–5. Sample line and contact drawing for a key system circuit.

We know that electric current is associated with voltage and resistance. These three factors are to be found in direct-current, alternating-current, and every other electrical circuit.

032. Using figures given, calculate the direct current, voltage, and resistance values for sample problems.

This section emphasizes the importance of using electrical circuit principles. Briefly, these principles include the following:

a. Ohm's law can be applied to any part of a circuit or to the complete circuit when two factors are known.

b. Current is the same in each part of a series circuit.

c. Voltage at each parallel branch is equal.

d. Total voltage is equal to the sum of the drops in series circuits.

Direct-Current Circuit Analysis. Let us look again at figure 4-1 and assume some resistance values for the purpose of analyzing this circuit.

Assuming that relay B has 400 ohms resistance, we can determine the current that is required to operate this relay. You should recall that a method used for making this determination is called Ohm's law. We know that according to this law, the resistance is divided into the voltage ($I = E/R$ or $I = 24/400$). As a result, the total current for our simple circuit is .060 ampere, or 60 milliamperes when contacts 3 and 4T of relay A are made (relay A is operated). Our analysis shows that the operation of relay B also completes the circuit to relay FL1. What, then, would a milliammeter register if placed between contacts 3 and 4T of relay B?

We immediately recognize that it is impossible to determine the current for relay FL1 while using Ohm's law because no resistance is shown for it. Again, we could assume a resistance to practice using this law. This is unnecessary since you used it with relay B, and we will use it again in this chapter. We want you to recall that by placing the milliammeter leads against contacts 3 and 4T, you have placed it in series with the circuit. This is a rule which you should remember. Likewise, you should place the meter controls so that the meter is prepared to read high value current, thus protecting the meter from damage.

The operated B relay also opens the operating circuit for relay A. Now, we realize that our previous statement in the above paragraph was not totally correct. Operated relay B moved contacts 3 and 4T together, but the operating circuit for relay FL1 was not really complete yet because contacts 1T and 2 of relay A are open until relay A is released. Consequently, you may consider relays B and FL1 as being parallel operated relays at the moment that relay A is released.

What are some of the rules that you learned about parallel devices in electrical circuits? The voltage across each device is the same and the current from the power source splits through the branches. This current is determined by the branch resistance and the total voltage. Furthermore, the total resistance in a parallel circuit is less than the smallest branch resistance. Figure 4-6 will help us review these rules. For instance, the 12-ohm resistor has only 2 amperes of current, whereas the smaller (8 ohms) resistor has 3 amperes.

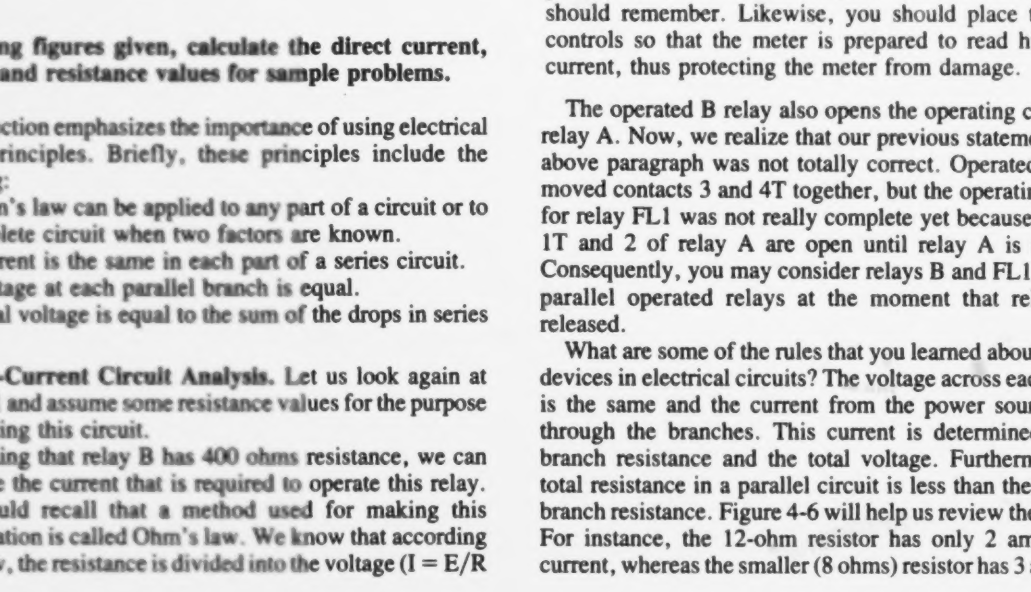

Figure 4–6. Sample electrical circuit.

Multiplying the current in each branch by its resistance reveals that the voltage for each branch is 24 volts. To determine the total resistance for the circuit, see Ohm's law (R = E/I). As a result, the circuit resistance is 4.8 ohms.

Exercises (032):

1. Consider relay FL1 of text figure 4-1 as having a resistance of 600 ohms. What current would be in the relay when the operating circuit is complete?

2. Assuming that the current for the operating circuit of relay A in test figure 4-1 is .015 amperes, what would be its resistance?

3. What voltage should be registered by the voltmeter of the circuit in figure 4-6?

033. Using figures 4-7 through 4-9, solve problems for typical balanced resistive bridge circuits.

The bridge circuit is basically a parallel arrangement with a load of some sort connected between its branches. It is used in numerous applications in the communications field, especially in test equipment and power supplies. Bridge circuits may be constructed with either fixed or adjustable components and may contain such items as fixed resistors, variable resistors, diodes, capacitors, or inductors. In addition, the bridge circuit may be regarded as balanced or unbalanced. We will first consider a balanced bridge.

Balanced Bridge Circuit. In figure 4-7 you can see a parallel circuit consisting of two branches, each having two series connected resistors. Current flows in each branch and the two currents join to return to the battery. Near the center of each branch are two terminals, identified as A and B. Figure 4-8 is the same circuit as figure 4-7, but the illustration is drawn to form the characteristic diamond shape of a bridge circuit. For the bridge to be complete, however, there must be a load of some kind connected between terminals A and B. This may be a resistor, coil, or any one of numerous electrical devices. In most test equipment, it is normal for the device in this position to be a galvanometer. The galvanometer shows the current that is flowing when the bridge is unbalanced.

What makes this bridge circuit balanced? The answer to this question is that a balanced bridge circuit has no potential difference between terminals A and B. A second question is: How do you determine when a bridge circuit is balanced? Two common methods are the ratio relation method and the Ohm's law method. We will first show the ratio relation method. In figure 4-9 the bridge circuit has had arrows added that show the relation between the four resistors. Note that R_2 is twice as large as R_1, and R_4 is twice as large as R_3. Therefore, we can see the relationship that follows:

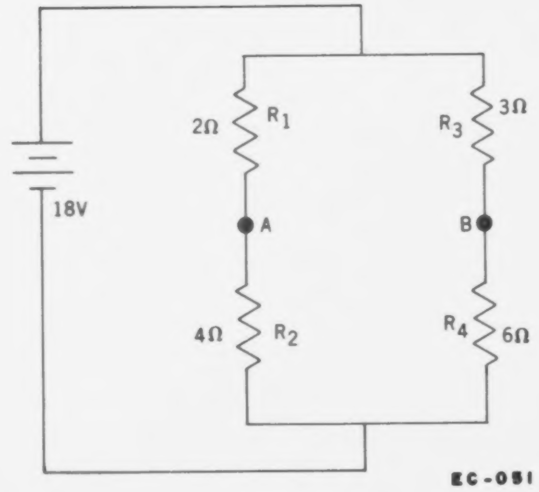

Figure 4-7. Series-parallel bridge circuit.

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad \text{or} \quad \frac{2}{4} = \frac{3}{6} = \frac{1}{2}$$

From the above problem, it can be seen that the two branches have an equal ratio. Furthermore, the ratio for resistors R_1 and R_3 is equal to the ratio for resistors R_2 and R_4 (2/3 = 4/6). Thus, the circuit is in balance.

To check the circuit by Ohm's law, we must determine the potential difference, if any, between terminals A and B. To do this, follow these four steps:

(1) Determine the resistance of branches A and B.
(2) Determine the current for branches A and B.
(3) Calculate the voltage for terminals A and B.
(4) Find the potential difference between terminals A and B.

Since the resistors in each branch of our bridge circuit are in series, we can add them to get the total resistance of that branch. To illustrate: 2 ohms plus 4 ohms in the A-terminal branch results in 6 ohms total. The B-terminal branch has 9 ohms. The voltage at each branch is equal to the applied voltage (18 volts). Now, we have the voltage and resistance; hence, we can solve for the current in each branch. Using I = E/R, we find the current to be 3 amperes in branch A and 2 amperes in branch B.

Return to figure 4-8 and picture R_1 as having 3 amperes and R_3 as having 2 amperes. Again, we have two factors for each resistor. Thus, we can get the voltage at those resistors by using Ohm's law. R_1 has a voltage drop of 6 volts and R_3 has a voltage drop of 6 volts. The same procedures are used to get the voltage at resistors R_2 and R_4.

Now compare the voltage at terminal A to the voltage at terminal B. Since both terminals are 6 volts negative in respect to positive battery, it is evident that the circuit is balanced. Of course, you can also consider the two terminals 12 volts positive with respect to negative battery. Again, this means that the circuit is balanced because there is no potential difference between terminals A and B. If a

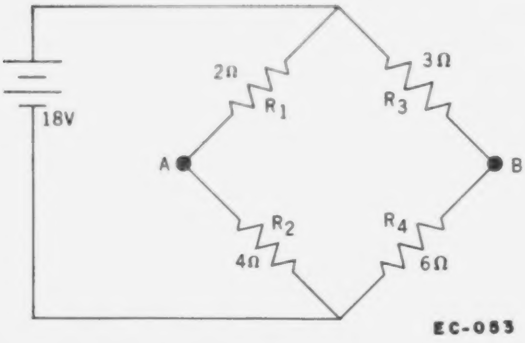

Figure 4–8. Basic bridge circuit.

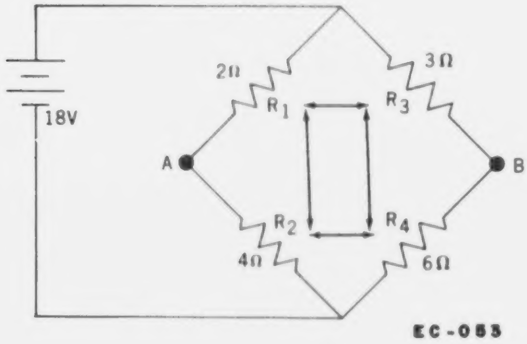

Figure 4–9. Relation between bridge resistors.

galvanometer is placed between terminals A and B, there will be no current flow through the meter.

Exercises (033):

1. Give the ratio for the listed resistors:
   R_1 = 1,000 ohms.
   R_2 = 10,000 ohms.
   R_3 = 500 ohms.
   R_4 = 5,000 ohms.

2. Using the resistance values R_1 = 100 ohms, R_2 = 50 ohms, R_3 = 150 ohms, and R_4 = 75 ohms for figure 4-8, determine the potential at points A and B.

034. Using figures 4-10 through 4-13 as needed, solve circuit values for an example unbalanced bridge.

Unbalanced Bridge Circuit. The unbalanced bridge circuit has a potential difference between terminals A and B. Therefore, current will flow in a galvanometer when connected between A and B. To solve for circuit values in an unbalanced bridge, use the methods described with the balanc bridge. Take the bridge of figure 4-10 as an illustration. Use the Ohm's law method and follow the four steps listed above, as follows:

Step 1 (resistance of branches):

$R_1 + R_2$ = 3 ohms + 12 ohms = 15 ohms
$R_3 + R_4$ = 6 ohms + 6 ohms = 12 ohms

Step 2 (current through branches):

$$I = E/R_AI = \frac{18}{15} = 1.2 \text{ amperes}$$

$$I = E/R_BI = \frac{18}{12} = 1.5 \text{ amperes}$$

Step 3 (voltage at points A and B, when compared to negative battery terminal):

$E_A = IR\ E = 1.2 \times 3$ ohms = 3.6 volts
$E_B = IR\ E = 1.5$ amperes $\times$ 6 ohms = 9 volts

Step 4 (potential difference between terminals A and B):

$E_B = E_A = 9 - 5.4$ volts

As you can see from the above calculations, point B in figure 4-10 is 9 volts positive with respect to the negative battery terminal. Point A is only 3.6 volts positive with respect to the same terminal. Comparing point A to point B, we see that B is 5.4 volts positive with respect to the former. This difference in potential permits current to flow from A to B whenever a load is connected between the two terminals. Of course, the current is determined by the size of resistance in the load and the potential difference of the terminals.

Adding a galvanometer to the circuit changes the total resistance. This in turn changes the current in the branch resistors. As a result, the voltage is changed for these resistors. To illustrate, assume that the resistance through a galvanometer is 0. A conductor with 0 ohms placed between terminals A and B results in making a new circuit. Compare

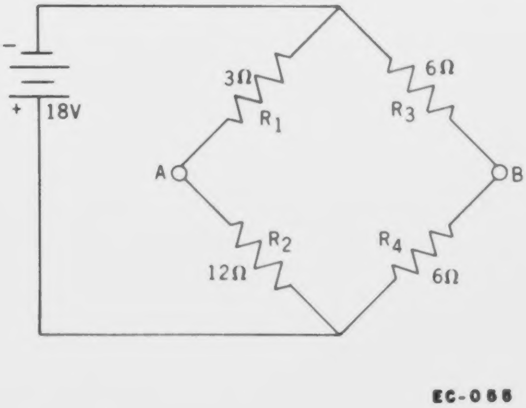

Figure 4–10. Unbalanced bridge circuit.

figures 4-10 and 4-11 and note the difference This short circuit has formed two parallel circuits. Also, the two parallel circuits are in series with the 18-volt power source. The following solutions show the new circuit values:

Step 1 (resistance of branches):

$$\frac{R_1 \times R_3}{R_1 + R_3} = \frac{3 \times 6}{3 + 6} = \frac{18}{9} = 2\,\text{ohms}$$

$$\frac{R_2 \times R_4}{R_2 + R_4} = \frac{12 \times 6}{12 + 6} = \frac{72}{18} = 4\,\text{ohms}$$

Step 2 (total resistance of branches):

$$B_1 + B_2 = 2\text{ ohms} + 4\text{ ohms} = 6\text{ ohms}$$

Step 3 (total current):

$$I = E/R \quad I = \frac{18}{6} \quad I = 3\text{ amperes}$$

Step 4 (voltage at each branch):

$$E = IR$$
$$E = 3 \times 2\text{ ohms} = 6\text{ volts (circuit 2)}$$
$$E = 3 \times 4\text{ ohms} = 12\text{ volts (circuit 2)}$$

Step 5 (currrent in each resistor):

$$I = E/R$$
$$I = \frac{6}{3} = 2\text{ amperes } (R_2)$$
$$I = \frac{6}{6} = 1\text{ ampere } (R_3)$$
$$I = \frac{12}{12} = 1\text{ ampere } (R_2)$$
$$I = \frac{12}{6} = 2\text{ amperes } (R_4)$$

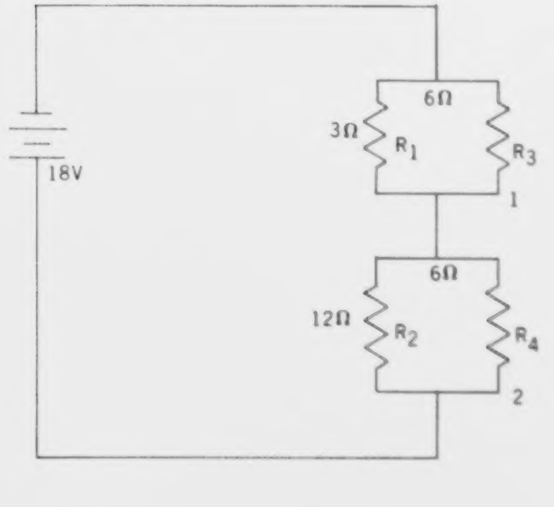

Figure 4-11. Two parallel circuits in series.

These new values, with a galvanometer between the terminals, are illustrated in figure 4-12. From this illustration, note that 2 amperes flow through R_1; yet only 1 ampere is shown for resistor R_2. In the same manner, resistor R_4 has 2 amperes while R_3 has only 1 ampere. It is evident, then, that 1 ampere must flow through the galvanometer (from point A to point B).

The solutions and description of the preceding paragraphs reveal that loading a bridge circuit with a galvanometer changes the current and voltage from that to be noted when the circuit is not loaded. This effect is true whether the load is low or high resistance.

We mentioned earlier that bridge circuits could contain variable components. Figure 4-13 shows a bridge circuit that contains a variable resistor. This resistor is used to balance an unbalanced bridge. When current is noted in the galvanometer of the bridge circuit, the control of the variable resistor is rotated until the current ceases in the galvanometer. Look again at figure 4-13 and determine the resistance required for R_3 when balancing the bridge. (NOTE: The slider reduces the resistance by short-circuiting resistance windings.)

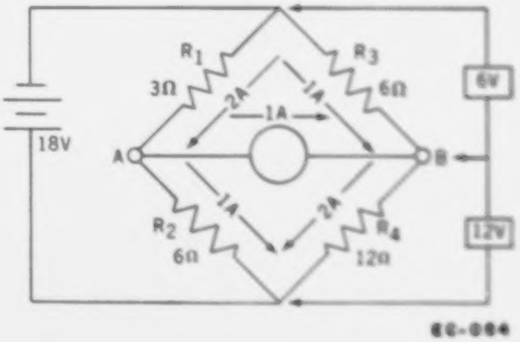

Figure 4-12. Galvanometer connected across bridge circuit.

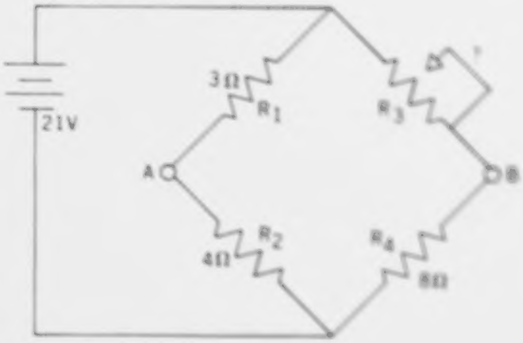

Figure 4-13. Bridge circuit with variable resistor.

The answer to this problem can be solved by the ratio method. By substituting X for the unknown resistance, we can solve the problem by using the ratio formula:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

thus

$$\frac{3 \text{ ohms}}{4 \text{ ohms}} = \frac{X}{8 \text{ ohms}}$$

therefore

$$4X = 3 \text{ ohms times } 8 \text{ ohms}$$
$$4X = 24 \text{ ohms}$$
$$X = 6 \text{ ohms } (R_3)$$

We can see now that R_3 must be reduced to 6 ohms to balance the bridge. Any other resistance, above or below 6 ohms, causes a potential difference between terminals A and B. This potential difference is indicative of an unbalanced bridge.

Exercises 034):

1. Use the resistors $R_1 = 12$ ohms and $R_3 = 36$ ohms with the circuit of figure 4-11 and determine the resistance for the parallel circuit consisting of these two resistors.

2. If the battery for the circuit of text figure 4-11 were 12 volts, what would be the total current of the circuit?

3. If the battery for the circuit of text figure 4-11 were 12 volts, what would the voltage at R_4 be?

035. State characteristics of AC current operating in primary and secondary circuits.

Alternating Current Circuit Analysis. Figure 4-14 illustrates a partial schematic diagram of a ringer. This ringer is equipped with several coils which enable the ringer to work when alternating curre passes through them. How is this action possible? The information in the following paragraphs provides the answer to this question.

Magnetic effects. One effect of current in a circuit is the creation of a magnetic field. Under certain conditions, current also produces light and heat. The effects that result from electron movement are basic to the operation of the telephone system. A telephone system uses relays which opera because of a magnetic field. It has alarms which also operate because of magnetic effects. The alarms are noticed because of lamps which operate as a result of current heating effects. Lamps also are supervision devices on switchboards. Heat is necessary for keeping a system dry, yet is unwanted when it is excessive. Electron flow can produce a chemical action. Additional actions that result from magnetism are alternating current generation, self-induction, and mutual induction.

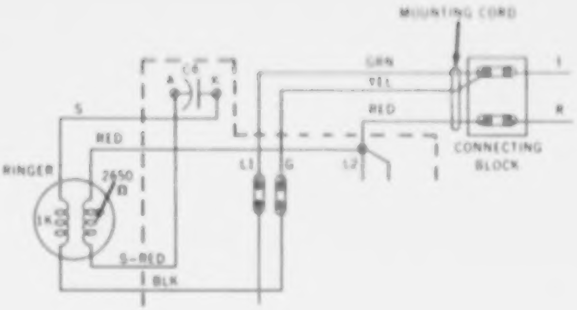

Figure 4-14. Partial telephone ringer circuit schematic diagram.

Mutual induction and self-induction are magnetic effects. Although magnetic effects may actually be inseparable, we will view them as individual elements.

You learned that the magnetic effects on the primary winding is called self-induction. The effects produced by the magnetic field of the primary moving into a secondary winding are referred to as mutual induction. In both windings, the induced voltage is in opposition to the inducing field's voltage.

Transformer action. A moving magnetic field provides the transformer action that develops voltage in the secondary winding(s). The magnetic field expands and thus moves through the primary winding and the secondary winding of the transformer. Keep in mind that mutual induction is achieved by magnetically linking the primary circuit of a unit to the secondary circuit. Such a linking device is called a transformer, an induction coil, or a repeating coil. The transformer can provide a greater or lesser voltage from the secondary than is applied to the primary, as well as an output voltage of the same value. (REMEMBER: The transformer output voltage is always AC whether the primary input is interrupted DC or AC.) The turns (loops) ratio between the primary and secondary determines the voltage relationship. You have learned that a transformer which has the most turns in the primary has an output voltage lower than its input voltage. Of course, a transformer can have a combination of step-up or step-down secondaries.

Because of the magnetic link between primary and secondary, it is logical that any change in one will affect the other. A decrease in the load (opposition) for the secondary can automatically increase current in the secondary and primary. This is a reason for a fuse becoming open in a primary circuit when a resistive device becomes shorted in electrical equipment.

Iron-core transformers are not normally used with radiofrequency circuits. The air-core transformer is used in conjunction with a capacitor or capacitors; and, as a result, they are made resonant (tuned) to a certain frequency or a band of frequencies. The type of response desired determines whether both the primary and secondary are tuned. In this equipment arrangement, the current of the secondary circuit has a negligible effect on the primary circuit. Changing the frequency or the capacitors changes the phase between the output and input voltage. (You have learned that an "in-phase condition" is where two or more sine waves pass through 0° to 180° simultaneously and reach peak values at the same time. An "out-of-phase" relationship is the reverse of in-phase.)

Impedance. The counter or back voltage of a self-inducing device, which has coils or windings, cannot be seen. However, its effects are very noticeable. Look at the coil of figure 4-15. This coil is shown with 50 ohms opposition. We know that hundreds of feet of wire are required to obtain just a few ohms of opposition; the resistance of wire is determined by the diameter of the wire and the wire type. Wire in the coil of our illustration, then, is not likely to provid the indicated opposition. The self-induction feature of the coil provides the impedance, the opposition for the circuit. The self-induction opposition of a coil is changed with AC frequency changes.

The opposition shown for the coil in figure 4-15 would be further increased if it contained an iron core. The iron core allows for a better transfer of magnetic flux between the conductor loops than does an air core coil. This is the reason for the increase in opposition. To illustrate, assume that the coil in our figure has 50 millihenries of inductance and that it is replaced with an iron core coil that has 1 henry of inductance. The opposition to the circuit current should increase to approximately 1,000 ohms.

Current generation. The demonstration shown in figure 4-16 is representative of those that you saw in the resident course. It reveals the three factors necessary for generating alternating current: a magnetic field, a looped conductor, and motion. You can see that the movement of the coil onto (fig. 4-16,B) and up from (fig. 4-16,C) the permanent magnet is reflected by the meter. The meter pointer moves first to the 5 at the right, then to the 5 at the left. The same principle is used in a generator. In the generator, the coil windings rotate through a permanent magnetic field.
The number of lines of magnetic force which are cut per second by the looped conductor determines the strength of the voltage induced in the conductor. There are a greater number of magnets and a larger number of conductors in generators than have been shown in figure 4-16. These additional conductors and magnetic poles result in an increase voltage and frequency for the generator's output over that which is developed in the demonstration. Remember that the same effects result if the magnet is moved and the coil is held immovable.

The major difference between AC and DC generators is their external connections. An AC generator has brushes and

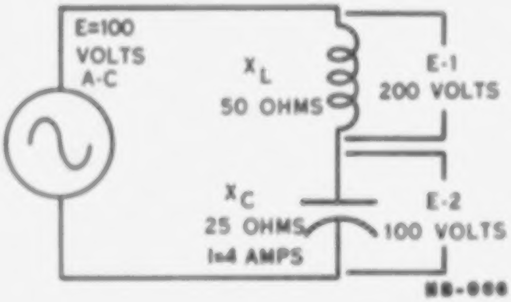

Figure 4-15. Series AC circuit.

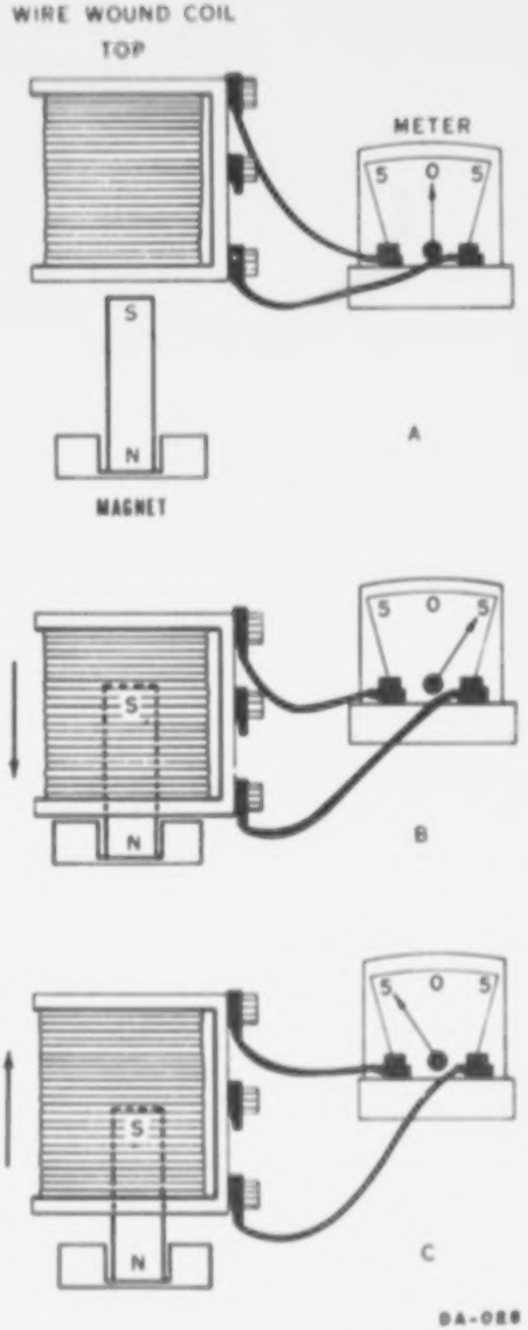

Figure 4-16. Generation of AC.

sliprings; whereas, a DC generator has brushes and a commutator. Figure 4-17 pictures two magnetic poles for a generator and the armature which rotates between them. The output voltage developed by this rotating armature is called a sine wave. The peak voltage is produced by conductors at the 90° and 270° positions of rotation. We are seldom concerned with these peak voltages, since the equipment normally operates with the effective value of AC. Each sine wave represents an AC cycle. The number of cycles provided per second results in the AC frequency.

NOTE: A frequency term that has been adopted in the electronic field is the word "hertz." Hertz has the same meaning as cycles per second, and it is abbreviated as HZ. By the same token, the term "kilohertz," abbreviated KHZ, has the same meaning as kilocycle.

Exercises (035):

1. List three additional actions that result from magnetism.

2. Define mutual induction.

3. How is mutual induction achieved?

4. If we decrease the load for the secondary circuit, what would be the effect on the primary circuit?

5. What are the three factors necessary for generating alternating current?

6. What type of external connections to AC generators have?

036. Distinguish between true and false statements concerning types of AC circuits and solutions to circuit problems.

It appears that the circuit of figure 4-14 has two unknown factors: (1) the applied voltage and (2) the current. A little consideration, though, should reveal that Air Force telephone systems use a ringing current from signaling. Generally this AC has a potential of 90 volts at 20 cycles per second. Thus, by knowing the applied voltage and the resistance, we can determine the circuit current using Ohm's law.

Resonance. Let us think about the circuit of figure 4-15 again. The current in the series circuit is 4 amperes and the opposition offered by the coil is 50 ohms. Using Ohm's law, you learn that the indicated voltage (200 ohms) is correct. You also should prove the values shown for the capacitor.

What else do you remember about the circuit of figure 4-15? Is it a resonant circuit? You should recall that the opposition of the inductor (X_L) must equal the opposition of the capacitor (X_C) when a circuit is resonant. This illustrated circuit does not show a resonant condition, since X_L is 50 ohms and X_C is 25 ohms. The frequency must be decreased to bring the two reactances to an equal value, since X_L decreases and X_C increases with this reduction. You also learned that the impedance of a resonant circuit is equal to the resistance, since X_L opposes X_C. In figure 4-15, the resistance would be slight at resonance because there is no resistor in the circuit. Consequently, with minimum opposition at the resonant frequency, the current is high. This illustrated figure also reveals another characteristic of an AC circuit with a series inductor and capacitor. The

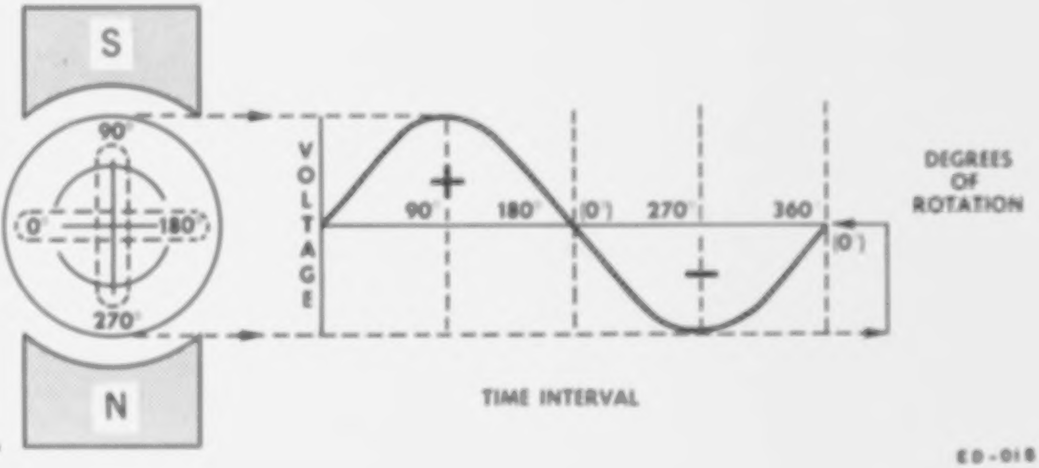

Figure 4-17. AC sine wave development.

voltage at each reactive device is high when compared to the input voltage.

A series-resonant circuit is used to filter out an undesired frequency from a circuit or as is often stated, "to pas the undesired frequency." It is effective because it appears as a short circuit to the resonant frequency but as high opposition to other frequencies.

Figure 4-18 illustrates a parallel arrangement of a capacitor and an induction coil. Since they are in parallel with the source of power, we know that each device has 100 volts applied to it. Thus, you can check the listed values with Ohm's law for AC to verify that they are correct. The total current for the circuit should restore to your memory that this type of circuit is characterized by having minimum current at resonance. Also, we can conclude that a circuit which has minimum current must have high impedance. The primary need in equipment with this type of circuit is voltage stability for one frequency and good discrimination against the off-resonance frequencies. Indeed, a parallel-resonant circuit is widely used in electronic circuits for restricting frequencies while passing another frequency or for passing a frequency and its band (closely related frequencies).

Exercises (036):

Mark a T for the true statements and an F for those that are false.

____ 1. The coils of the ringer in figure 4-14 are parallel connected.

____ 2. The circuit of figure 4-18 is resonant.

____ 3. Assuming 90 volts for the 1000-ohm ringer winding in text figure 4-14, the current is approximately 9 amperes.

____ 4. The current in the inductor of figure 4-15 is 4 amperes.

____ 5. The total opposition for the circuit of figure 4-18 is 200 ohms.

4-5. Principles of Trouble Analysis

Searching for trouble is part of your job. Thus, you should know the types of faults that plague telephone equipment, and you should understand the conditions that cause these faults.

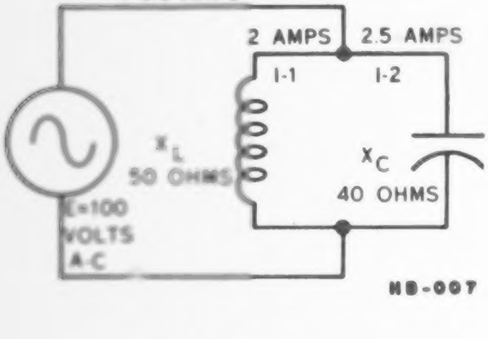

Figure 4-18. Parallel AC circuit.

037. Name common circuit troubles and list procedures for troubleshooting them.

Troubleshooting Procedures. Successful troubleshooting results from good procedures, accurate thinking, and practice. Troubleshooting requires you to think logically and use a sequence of basic steps. Study your telephone equipment so that you know the trouble symptoms and where to start looking for troubles when a symptom is noted.

Common Troubles. Once you have identified a trouble symptom, try to analyze the equipment and isolate the fault to a particular unit or circuit. An analysis, however, seldom determines a specific component within the unit as being open- or short-circuited. Your experiences have shown the meaning of open circuit and short circuit. An open circuit has no current because the circuit opposition is infinite. A shorted circuit has less than normal resistance and an increased current. If you need further review, their definitions are included in the glossary. You may see an intermittent (disappearing) open or short. This type of trouble is caused by a loose connection or a temporary moisture condition. Visual inspection may be the only method for finding the defect. Permanent troubles are generally found by analysis and testing, since they remain in the equipment.

Summarizing, then, a systematic troubleshooter observes the trouble symptom(s), inspects the equipment, analyzes the circuits, isolates the fault to a particular unit, and localiz the trouble by thinking and testing. By following the circuit while using a systematic process of elimination, you can usually locate the fault in a minimum of time. This procedure eliminates the good circuit parts in sequence.

Exercises (037):

1. What is the circuit condition following the "blowing of a fuse"?

2. Specify a telephone circuit fault that is often most noticeable during a thunderstorm.

3. Tell the three preliminary procedures during telephone system troubleshooting.

4. What subsequent procedures are used to localize the fault?

038. Relate sample trouble symptoms to defective circuit components.

Trouble Symptoms. One equipment trouble symptom is the failure of a lamp to light. In another circumstance, a trouble could light an equipment lamp. Also, we have noted that another trouble symptom is a blown fuse. Replacement of the fuse without knowing that the short circuit is corrected is not a proper procedure. You could burn out the second fuse. Therefore, you should open the equipment on/off switch and inspect the equipment. Look for blackened components, loose wires that are touching neighbor wires or terminals, and devices that have strong, strange odors.

Noise is also a circuit trouble symptom. An open filter capacitor and a shorted coil will cause noise because they reduce filtering for the power circuit. Since capacitor input filters are highly charged at the instant of "switch on," they are often more troublesome in electronic circuits than are coils.

Exercises (038):

1. Match typical trouble symptoms in column A with the device that caused it in column B. A device may be used more than once.

Column A	*Column B*
____ (1) Noise.	a. Open key.
____ (2) Dark lamp.	b. Blown fuse.
____ (3) Strong odor.	c. Loose wire.
____ (4) Burnt component.	d. Open capacitor.
____ (5) Glowing lamp.	e. Shorted coil.

039. Given example trouble symptoms, determine probable equipment troubles.

Trouble Analysis. When one parallel branch is opened, the total resistance of the circuit must increase. Figure 4-19 should help you to recall this. Before resistor R_3 opened, the total resistance equaled 15 ohms. With R_3 open, the total resistance equaled 18.75 ohms. If the circuit is opened between the power source and R_1, there would be no current flow. Thus, the condition is comparable to opening a switch in a series circuit. If one of the resistors (R_1, R_2, or R_3) is short-circuited, the total resistance then equals 0 ohms. If a short-circuited branch of a parallel circuit results in 0 ohms, what effect would a short across resistor R_2 in the circuit of text figure 4-6 have on the ammeter. Yes, the meter would show greater current. A normal circuit has a fuse and it will blow following a short circuit.

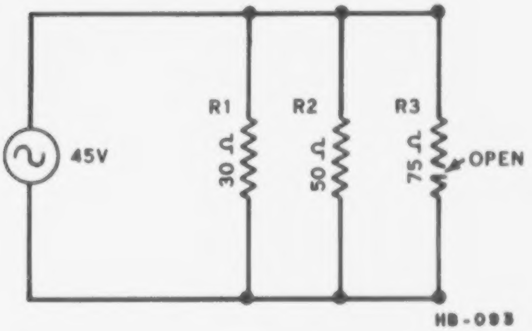

Figure 4–19. A parallel circuit with an open branch.

Let us think about another failure that may be applicable to your work. In this instance, you have depressed the keyset HOLD pushbutton, but the HOLD lamp has not lighted. We need to consider whether the trouble is just the lamp, or whether it is also the hold relay. If it is only an open lamp, the call circuit will be disconnected as normally required. You can determine this by listening to the receiver while talking to the party being held. Receiving no reply from this party indicates that the operated hold relay has progressed the actions to where a relay opens the transmitter circuit to this party. Replacement of the lamp should correct this open circuit.

We will now make an analysis of other possible circumstances. The symptom of trouble is that the HOLD lamp has operated following depression of the HOLD pushbutton, but the hold relay appears not to have operated. You determine if the relay has operated by talking and then listening for a reply from the party being held. If you hear a reply, you know that your transmitter circuit was not opened, possibly because of a hold relay failure. Surmising that the hold relay is failing, we should question whether the trouble can be an open, a short-circuit, or a maladjustment of the contact springs. The relay winding could be either short-circuited or open, resulting in its failure to operate. We know this to be true because an open winding prevents current; whereas, a short circuit bypasses the current around the winding. Maladjusted relay contacts are more likely to be trouble causes than are open or shorted circuits.

CAUTION: Never touch relay adjustments unless tests indicate that it is necessary to do so. Each system usually provides a test set with which you can determine the condition of the relay. A relay is not often checked individual because it is a part of a circuit. Your test of the circuit reveals the condition of the components.

You would use test equipment to check the resistance of the suspected components. However, you must isolate the parallel components to insure that your test is accurate.

Safety should always be a primary consideration when working with electronic circuits. You can be harmed by transient voltages. The manufacturer installs devices for the high voltages in a specific manner to protect the equipment and the personnel. You need not think about his or her reason for this arrangement, but you must think about the precautions to take when working with his or her equipment. For instance use a test lead and short circuit the input capacitor to insure that the high voltage is discharged.

If you are to fully understand a telephone system, it is necessary that you be familiar with its development and its operating principles. (Remember: The better you understand the fundamentals of electricity, the easier it will be for you to complete the following volumes in this course.)

Exercises (039):

1. Assuming that relay FL1 in the circuit of text figure 4-1 does not restore fully after relays B and A are restored, what circuit component should be tested for a short?

2. Having lifted the handset and operated PICKUP key 1, you find that you can't receive from the caller. What defects and which key contacts of figure 4-3 could cause this condition?

3. A voltage test across R_2 for the circuit of text figure 4-11 results in 0 volts. What is the probable cause for this reading?

4. Assuming that the 1K ohm winding of the ringer (fig. 4-14) is blackened and has a burnt odor, what defect should you suspect?

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CHAPTER 5

Basic Electronic Circuits

A SUCCESSFUL space flight of 325 million miles began 28 November 1964 and reached its climax 14 July 1965. The encounter of the spacecraft with Mars, although it was still approximately 6,000 miles from the planet, resulted in picture recording. The stored pictures were then transmitted a distance of 134 million miles at a rate of 8⅓ bits per second; it required approximately 8 hours and 20 minutes to play back each picture to earth.

Many people and many things made this venture successful, two of which are solid-state devices and logic circuits. These devices also have advanced telephone and other communications systems to their present dependable, secure, and serviceable status.

You have learned principles of construction and operation for the devices and have analyzed some logic circuits. Therefore, we will need only to review some of these principles. Where circuit descriptions are covered, we will present an analysis that may be different from your previous study. Hence, you will again see the need for knowing the fundamentals of a subject if you are to become a technician.

5-1. Solid-State Devices

Current flow is a familiar term to people in electronics. The movement of electrons has been noted in wires, tubes, and N-type semiconductor material. The P-type semiconductor material is useful because current is produced by moving holes. You know that the electron has a negative charge; whereas, the hole denotes a positive charge. The two types of semiconductor material have been joined together to form a solid state device.

040. Using figures 5-1 and 5-2 as required, distinguish between true and false statements concerning PN-junction characteristics.

Fusing two types of semiconductor material together resulted in a unit called a PN junction. This unit is useful because of the current at its surface.

PN Junctions. You learned in the electronic principles training at the resident course that when the P-type and N-type semiconductor materials are combined, the greatest amount of current is noted only when you connect power in a certain polarity to the PN junction. Power can be connected, so that the junction has either forward bias or reverse bias. The forward-bias connection provides the most current. Figure 5-1,A, shows approximately 1 milliampere of current in the meter when forward bias is provided. Furthermore, current is minimum when the PN junction is connected for reverse bias (fig. 5-1,B). Current in a reverse-biased PN junction is usually measured in microamperes. You also should recall that forward bias results when the P-type material is connected to the positive terminal of the power source. Hence, reverse bias results when you connect negative of the power source to the P material.

Applying reverse bias to a junction diode has proved valuable in electronic circuits, although this condition is used less than is the application of forward bias. While current is in the diode, the voltage across the device remains almost constant. Remember that this effect is similar to the characteristic of a gas-filled voltage regulator tube. In transistorized equipment you may see the zener diodes used as voltage regulators, since they are small, have excellent regulation characteristics, and require a minimum of power. Figure 5-2 shows the principle of voltage regulation while using a zener diode. When the input voltage has increased, a greater voltage is applied to series resistor R_1 and zener diode CR_1. This voltage increase causes the diode to conduct more current. Nevertheless, an increase in current does not cause a voltage change at the terminals of the diode. Since the load is parallel to the diode, it likewise has no change in voltage. Changes in current or voltage in the power source or in the load are compensated for by the zener diode.

Many electronic power supplies use silicon diodes as rectifiers. Their small size, light weight, reliability, lack of a need for filament heat, and high-voltage ratings are reasons for their use. They can be used with a half-wave, full-wave (bridge type), or center-tapped transformer rectifier circuit.

Exercises (040):

Place a T in the blank before the true statements and an F before the false statements.

____ 1. The greatest current flow is in a forward-biased battery circuit.

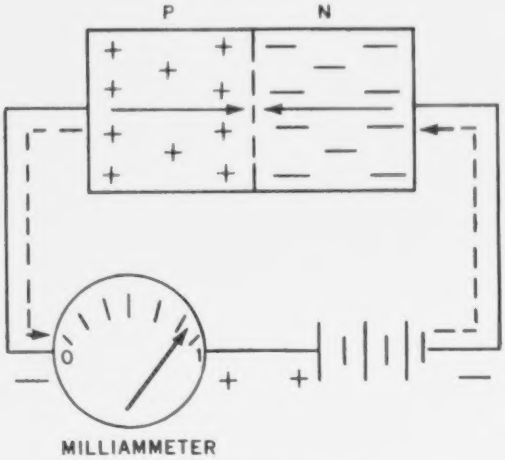
____ 2. The B battery (fig. 5-1,B) is providing maximum current.

____ 3. The voltage for a PN junction (figs. 5-1,A, and B) is about the same when forward- or reverse-biased.

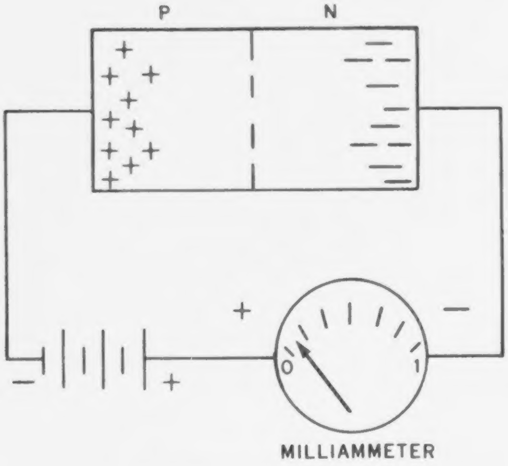
____ 4. CR_1 of figure 5-2 rectifies alternating current.

____ 5. Current for the load of figure 5-2 is always equal to the current in CR_1.

041. Using figures 5-2 and 5-3, compare a PN junction with a transistor.



A. FORWARD BIAS



B. REVERSE BIAS

Figure 5–1. Biasing of solid-state devices.

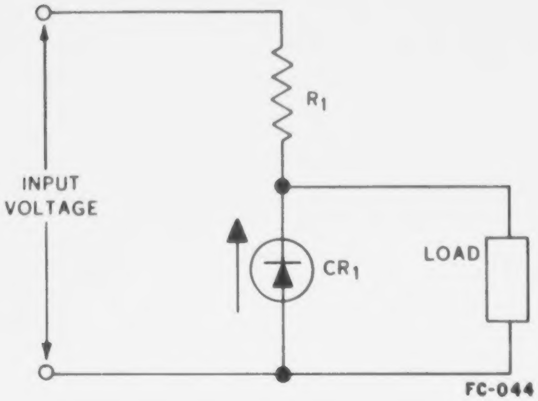


Figure 5–2. Zener diode as a voltage regulator.

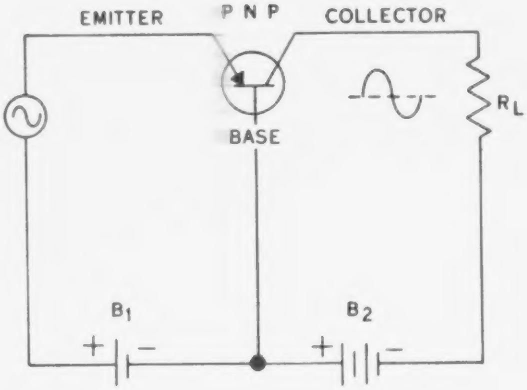


Figure 5–3. Common-base amplifier schematic diagram.

Adding a third section (either a P- or N-type material) to a PN junction results in a transistor. To operate the transistor, the power is connected so that both forward-bias and reverse-bias are applied to the device.

Transistor Circuits. Figure 5-3 permits us to review the transistor symbol, the names of its parts, and its current flow. The three parts to a transistor are the base, collector, and emitter. The main current flow is from the emitter to the collector. The emitter-to-base junction is normally forward-biased, and the base-to-collector junction is biased in the reverse direction.

The generator symbol within the circuit of figure 5-3 indicates that an oscillating potential can be placed in the circuit, in addition to the battery potentials. Consequently, the voltage for the base-emitter junction will be alternately slightly higher than or slightly lower than the bias set by the battery. For instance, if the voltage of the bias battery is 6 volts and the generator's signal is .5 volt, the control voltage will vary from 6.25 volts to 5.75 volts. You should recognize that the circuit of figure 5-3 is a diagram of a very simple transistor circuit.

A transistor requires a minimum of power, takes very little space, and resists mechanical shock while operating very efficiently. In addition, it does not deteriorate while operating. It is used for amplification and switching in electronic equipment. The switching may be either low or high speed.

Exercises (041):

Using figures 5-2 and 5-3, select the applicable characteristics given below, by placing the referenced figure(s) in the space provided. You may use both in some blanks.

____ 1. Several milliamperes of current flows from the emitter to the collector.
____ 2. The reverse-biasing battery is connected between the base and collector.
____ 3. The circuit load current varies constantly.
____ 4. The voltage at the circuit load varies.
____ 5. The output current and voltage are affected by an incoming AC signal.
____ 6. The base connection to negative battery results in forward bias.

5-2. Electronic Circuit Analysis

In the resident course, you traced many circuits, such as transmit circuits, ringer (signaling) circuits, amplifier circuits, 1A1, 1A2, and 6A telephone circuits. It is evident, then, that there are many types of electronic circuits and many methods used to develop circuits which accomplish the same function. Of course, we will not consider all of the types of circuits nor the ways in which they are developed. We will only review sample transistor amplifier circuits and reconsider trouble analysis while using example electronic circuits.

042. State two uses of transistor circuits and name three classes of amplifiers.

Amplification makes possible many functions. For instance, it provides that one circuit stage will develop a certain strength signal for a second stage, or it provides more than one circuit stage with different strength input signals, or it permits a circuit to provide an oscillating output. Let us look now at sample amplifiers.

Amplifiers. You have seen that voltage, current, or power can be increased (amplified). The input signal strength to a transistor can be amplified as high as 1,000 times by the transistor (stage). Gain is described as the ratio between the input and output signals. For example, the signal strength of the generator in figure 5-3 is .5 volt. Assume that the voltage at the collector connection (or load resistor) varies from 60 to 65 volts (5 volts change). As a result of these readings, we can determin that the signal strength has been increased 10 times by the transistor amplifier. The connections which make transistor amplification possible are not always the same, because we want a variety of results. Thus, we saw that transistor amplifiers are classified as follows:

- Common-base amplifier.
- Common-emitter amplifier.
- Common-collector amplifier.

Exercises (042):

1. What is the function of a transistor that increases the emitter to collector signal by 100 percent?

2. List three useful transistor amplifiers.

043. Using figures 5-3 through 5-6, compare transistor amplifiers.

Common-base amplifiers. Common-base amplifiers are also referred to as grounded base amplifiers. Figure 5-3 illustrates a common-base amplifier. This type of circuit has very low current amplification and a moderate voltage and power gain; consequently, it is not the most valuable amplification device. The circuit reveals that the input signal is applied to the emitter and that the output signal is reflected by the load resistor. If an NPN transistor had been used rather than the PNP transistor, the batteries would have been reversed; but the voltage phase relationships would have remained the same. In other words, any positive change at the emitter causes an increase in voltage across the load resistor. With the preceding changes, a signal reading at the collector would temporarily be more positive. Vice versa, a negative signal at the circuit input results in a more negative signal at the collector output terminal.

Common-Emitter Amplifiers. Common-emitter amplifiers provide high voltage and power gain; thus, they are used almost exclusively in amplifier circuits. In addition, they yield a moderate current gain. Figure 5-4 reveals an amplifier stage that has the emitter connected to a grounded resistor—with the base receiving a signal from a coupling capacitor. Another feature of this type of amplifier is the phase-reversal between the base and the collector. Therefore, a positive signal at the base results in an amplified negative signal at the collector. Note that the operating principle for this amplifier is opposite to the principle which you noted in the common-base amplifiers. Although the contrasting factors are the biasing battery and the incoming signal, the positive incoming signal for the emitter amplifier opposes the bias voltage. This is contrary to the effect you noted in the common-base amplifier. Hence, the negative signal at the common-emitter amplifier also is opposite in effect to the negative signal at the common-base amplifier.

REMEMBER: Each small change to the bias voltage developed by resistors R_1 and R_2 results in a large change at the output of the stage. For example, 1 milliampere of change at the input can result in a 10-milliampere change at the output. Resistor R_3 stabilizes the amplifier by following the changes in collector current. For instance, an increase in collector current causes the voltage at R_3 to increase. The reduction in potential between the base and emitter reduces the bias current, thus keeping the amplifier within its correct operating characteristic.

Common-Collector Amplifiers. Common-collector amplifier characteristics are low voltage and power gain and moderate gain in current. Therefore, this is used only in special circuits. For instance, it is useful as an impedance matching unit. Figure 5-5 shows the collector connected to ground and the emitter with a positive potential when compared to the collector. Likewise, the input signal from the preceding stage is applied to the base. This amplifier

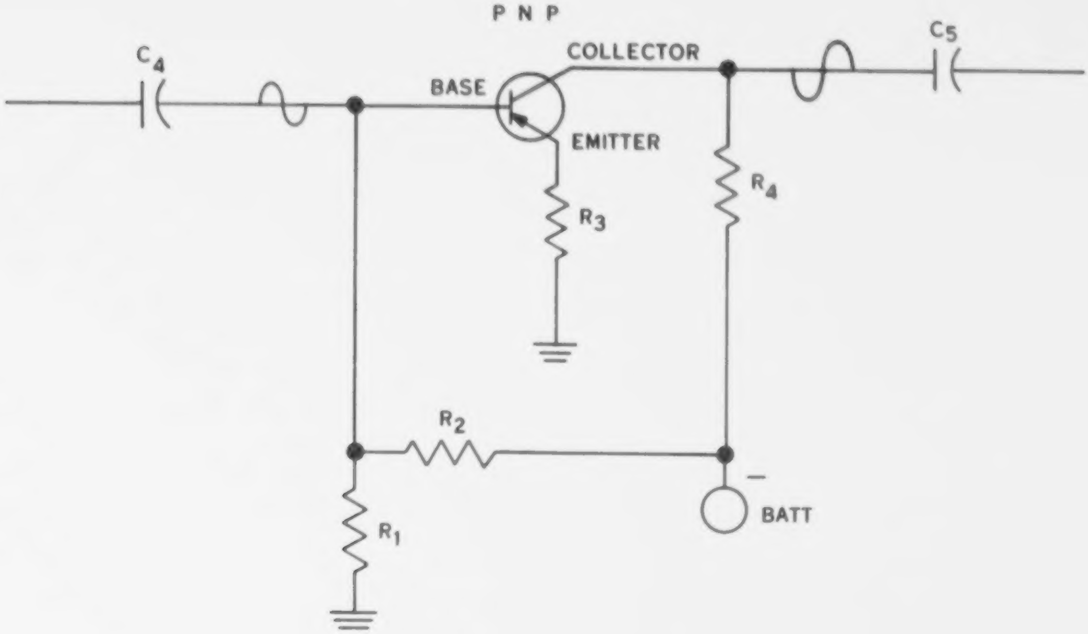

PNP
C4
COLLECTOR
C5
BASE
EMITTER
R4
R3
R2
R1
BATT

Figure 5–4. Common-emitter amplifier schematic diagram.

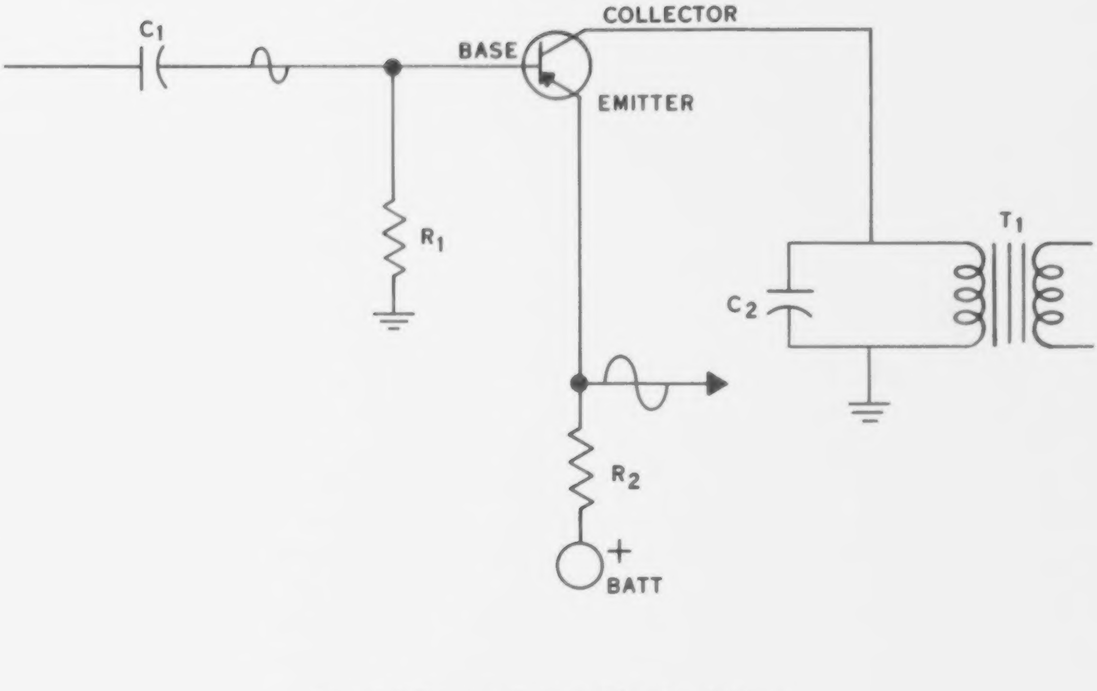

C1
COLLECTOR
BASE
EMITTER
R1
T1
C2
R2
+
BATT

Figure 5–5. Common-collector amplifier schematic diagram.

stage compares with the common-base amplifier in that it has no reversal of phase between the amplifier input and output. It is easily seen, too, that the output signal can be taken from the emitter. A negative input signal at the base of the transistor of figure 5-5 results in an increase in current at resistor R_2. Consequently, the voltage drop at the resistor is greater following the signal application than it has been before the employment of negative signal. Accordingly, the increased voltage at the resistor results in a more negative output signal. Thus, an emitter voltage change follows directly the base voltage change. We can see the basis, then, for referring to the transistor as an emitter-follower amplifier.

The common-emitter circuit is the most acceptable transistor amplifier. You learned during your study that it is useful in many ways. For instance, it can be used as an IF amplifier, RF amplifier, class A amplifier, class B push-pull amplifier, or in several other applications. Let us now consider a representative amplifier circuit and determine some of its effects.

Typical Class A Amplifiers. Figure 5-6 is a schematic diagram of a class A amplifier stage. Collector current will be in this transistor continuously. A preceding amplifier, such as a vacuum tube or a transistor, furnishes the input signal through a coupling transformer. The output signal from our illustrated amplifier is coupled by a transformer to the succeeding device. Series resistors R_1 and R_2 provide bias voltage, while R_3 provides stability and keeps the stage operating within its normal linear characteristic. Any change in the R_3 resistance will result in a distorted output signal, although the input signal is normal. In the same manner, a change in the resistance of either R_1 or R_2 will affect the bias current, which in turn distorts the output signal. This amplifier stage is not often troubled with heat damage when used as a preamplifier because current is small. If a class A amplifier is used as a power stage, high temperature could result from the heavy current flow. You will then see that temperature-compensation components are included in the power-output stages. These compensation devices provide a current feedback and produce some signal distortion. One such compensating device is the thermistor, which has a decrease in resistance when the temperature rises.

Exercise (043):

1. Match the amplifier in column B with the amplifier characteristic statements in column A that best relate to the specific circuit. Place the applicable letter(s) in the blank before each statement. Each amplifier can be used two or more times.

Column A

___ (1) High voltage and power gain.
___ (2) Constant current.
___ (3) Low current amplification.
___ (4) RF amplifier application.
___ (5) No phase reversal.
___ (6) Emitter-follower application.
___ (7) Amplified signal phase reversal.
___ (8) Emitter connects with grounded resistance.
___ (9) Collector requires connection to negative battery.
___ (10) Impedance-match usefulness.

Column B

a. Common-base amplifier.
b. Common-emitter amplifier.
c. Common-collector amplifier.
d. Class A amplifier.

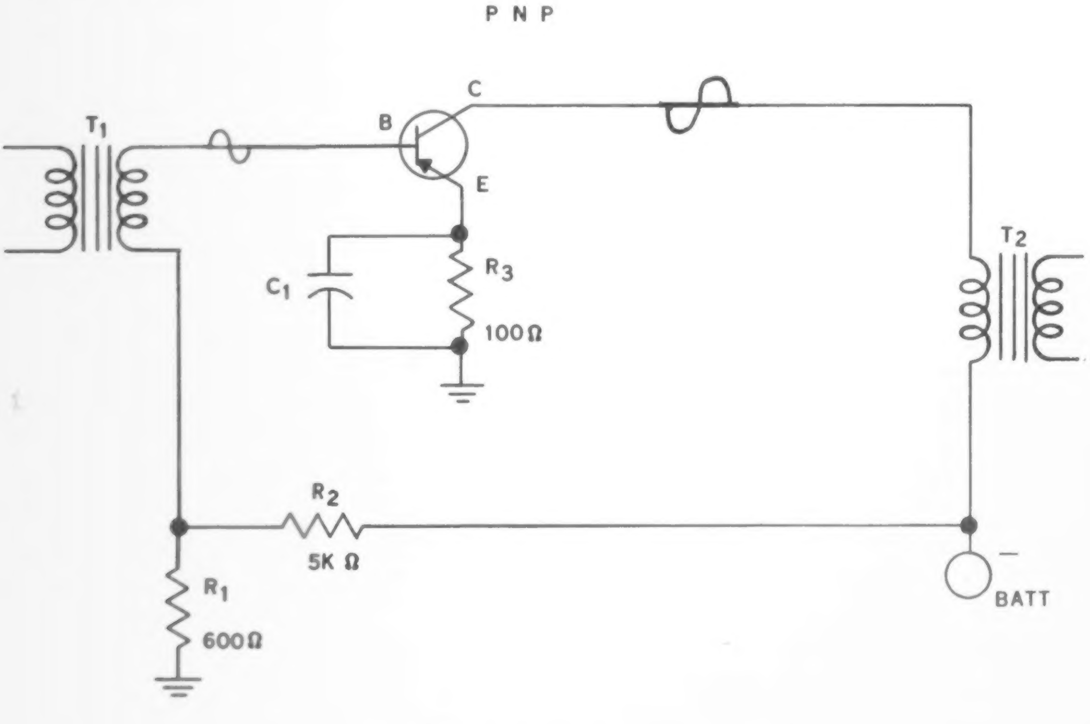


Figure 5–6. Schematic diagram of a transistor class A amplifier.

044. Identify trouble symptoms and probable causes.

Most types of electronic equipment have fuses protecting the major circuits. When the current increases in such a circuit, the fuse blows (opens). As a result of the fuse blowing, an alarm or alarms may operate. There may be only a lamp or there may be a lamp and an audible alarm (buzzer or bell). This alerting action is of no use, however, if the repair technician does not understand the meaning of the signal or cannot correct the trouble.

Trouble Analysis. To be a good troubleshooter, apply the basic rules and follow a logical sequence of steps. Carefully study your communications circuits and equipment so that you know where to start looking for troubles when the need arises. Also, become familiar with the equipment technical orders and with the circuit values to be expected when checking the circuit test points.

A systematic troubleshooter observes the trouble symptom(s), inspects the equipment, analyzes the circuits, isolates the fault to a particular unit, and localizes the trouble by thinking and testing. By tracing the circuit while using a planned method for eliminating good circuit units in sequence, you usually can locate the fault in a minimum of time.

Typical trouble symptoms and causes. Not all circuit troubles are so readily identified as those in circuits which have fuses. Because of the multiplicity of equipment and connections, a person must take note of the trouble symptoms and analyze the circuit for probable reasons for the trouble.

You have seen that a lighted alarm lamp is often a symptom of trouble. Yet, a dark lamp could also be a trouble symptom. Many trouble symptoms are possible, but it is very probable that there will be fewer symptoms than troubles. Strange as it seems, this is a true statement, since there is usually more than one trouble that gives the same trouble symptom. For example, if a fuse alarm lamp is dark following the blowing of a fuse, you could assume that the lamp needs replacement. Yet, it is possible that the fuse contact which completes the lamp circuit is defective.

A meter could also be considered to be an electrical-type trouble indicator. It operates because of current in the windings of the meter movement. It compares to the fuse alarm lamp in that, when it is not operated, it shows that a circuit is faulty. Yet, in some testing arrangements, an operating meter identifies a circuit as being in trouble.

We have noted some of the methods which indicate that the equipment is not functioning properly. Having been alerted to the equipment failure, you must then inspect and test the circuits to isolate the cause for the problem. Look also for additional symptoms. For instance, inspect for blackened components; loose wires; broken parts; devices that have strong, strange odors; abnormal signals; etc.

Exercises (044):

Place an S in the blank before the number that denotes a trouble symptom and a C in the blank that designates a cause for a trouble symptom. Some blanks will require both letters.

____ 1. Open fuse.
____ 2. Short-circuit.
____ 3. Dark lamp.
____ 4. Low voltage.
____ 5. Open contacts.
____ 6. Lighted lamp.
____ 7. Loose wire.
____ 8. Distorted sine wave.
____ 9. Buzzing.
____ 10. Fluctuating current.

045. Study given circuits and trouble symptoms and isolate the probable trouble.

Trouble Isolation. Return to figure 5-6 and assume that the output signal is distorted. Since a short-circuited capacitor in an amplifier circuit or an open-biasing resistor could cause such a change, capacitor C_1 and resistor R_1 are probable defects for this trouble symptom. An open resistor R_1 in figure 5-5 likewise could distort the signal at R_2.

If you were using a clickset to trace the signal in a transmit circuit that included the circuit of figure 5-5 and received a noisy (abnormal harmonic) sound at T_1, capacitor C_2 may be suspected. An open capacitor often results in noise at the circuit output.

Assuming that a fuse protecting the equipment containing the circuit of figure 5-4 has blown, you should suspect a reduction in resistance in the battery circuit. Resistors R_1, R_2, and R_3 are probable suspects. Of course, to determine if one is short-circuited, you must disconnect each resistor from the circuit and measure for 0 ohms resistance.

Our description of trouble analysis has been very limited, because we used simple circuits which have few probable troubles. Your trouble location will likely be more inclusive. Furthermore, it will be more effective; because you will have the equipment available and will use technical order troubleshooting procedures and remedies. (REMEMBER: A good understanding of the circuit's development provides for efficient trouble location.)

Exercises (045):

1. What is a probable defect in the circuit of figure 5-4 if the signal at C_5 is distorted?

2. What is a probable defect in the circuit of figure 5-5 if a fuse in the secondary of T_1 is blown?

CHAPTER 6

Telephone Fundamentals

TO INSTALL and maintain telephone equipment, you must understand how telephones and telephone systems operate. In the previous chapter, we discussed basic electrical undamentals and circuits. In this chapter we will explain how these electrical fundamentals are applied in the transmission of sound.

The sound of the speaker's voice is not actually transmitted over long distances, but a sound similar to the voice of the speaker is generated at the distant point by means of electrical power. The sound of the speaker's voice is transformed into electrical power at his or her telephone, transmitted over wires to any given point, where it is changed into sounds that resemble the voice of the speaker. You must be familiar with the various systems and equipment that are used to transmit the sound in electrical form.

This chapter will briefly review sound, the telephone components which affect sound, and typical telephone circuits and systems.

6-1. Sound Generation and Transmission

The movement of the air molecules set up by a moving part produces sound waves which travel outward in all directions. Figure 6-1 illustrates sound waves and their direction of travel. These sound waves result from the condensation and dispersion of the air molecules.

046. State the procedures for sound generation, transmission, and conversion.

You learned in the resident course that the motion of air molecules set up by a vibrating body (vocal cords, musical instruments, etc.) produces sound waves which travel outward in all directions from the vibrating source.

Sound Generation. The manner in which sound waves are produced can be understood by considering a vibrating strip of metal, such as the hacksaw blade illustrated in figure 6-2. While looking at this illustration, imagine that the hacksaw blade is fastened to a table in the vertical position and that it is at rest as shown at A in the illustration. Now, if the blade is caused to vibrate rapidly back and forth, two events of opposite nature will occur as the blade makes it initial trip to the right. These two events, as shown at B in the illustration, are: (1) the blade increases the pressure in the group of air particles on its right, causing a bunching-up of the particles on that side; and (2) the blade decreases the pressure in the group of air particles on its left, causing local rarefaction of the particles on that side. This rarefaction on one side and bunching-up on the other occur at the same time and are caused by the single motion of the blade to the right.

While looking at B in figure 6-2, note that movement of the blade to the right imparts motion to the particles on each side of the blade. As you can see at C in the figure, by the time that the blade has returned to the center, there is a wave of pressure (bunched particles) moving outward on the right side and a wave of low pressure moving outward on the left side. In reference to D, you can see that as the blade moves to the left, a wave of bunched particles is established on the left side and a rarefaction of particles on the right side. As the blade continues to vibrate (see E and F of fig. 6-2), the waves move outward on both sides of the blade. These waves of both bunches and rarefied particles are the waves that strike the sensitive membranes of the ear, causing the sensation of sound.

As the sound waves continued outward from their source, the air particles that transmit the energy do not go along with them. Rather, they collide with their outside neighbors, impart their energy, and return to a point close to their original position. The outside neighbors then react in a similar manner by relaying the energy to their outer neighbors, etc. until the energy is all dissipated at some distance from the source. Science compares this effect of sound in the atmosphere with the rings formed in still later when a stone strikes the water's surface. The stone causes a disturbance in the water and creates a series of waves. Similarly, a gunshot creates a disturbance in the atmosphere. It also creates waves through the process of arefaction and bunching of atmospheric particles.

Sound Transmission. Sound waves moving in the vicinity of a person will stimulate the nerves and auditory centers of the brain, hence the person hears the sound. The stimulation, of course, is caused by vibrations or sound waves which are transmitted to the ear through a material medium, such as air or atmosphere (see fig. 6-1). The sensation of sound is caused by physical vibrations occurring about us in the atmosphere. For example, when someone is speaking to you, the vibrations caused by the speaker's vocal cords are recognized by your ears as sound. Sound waves may be shown graphically in much the same manner as showing alternating current with a sine wave. As a matter of fact, when a group of sound waves are of identical shape and amplitude, they may be represented by a pure sine wave. If the waveshape is regular in form, the sound we hear may be a steady tone; if the shape is irregular, we may only hear a noise. As an example of graphic representation, look again at figure 6-1, where the sound wave is plotted as a line and the

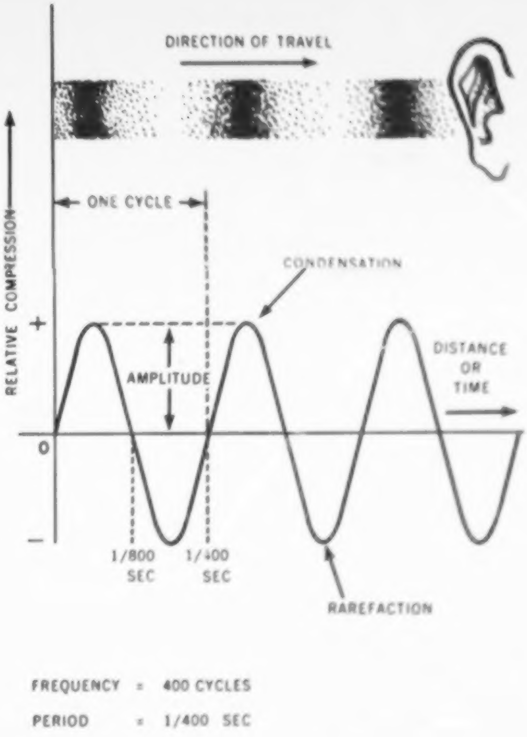


Figure 6–1. Waveform of a simple sound.

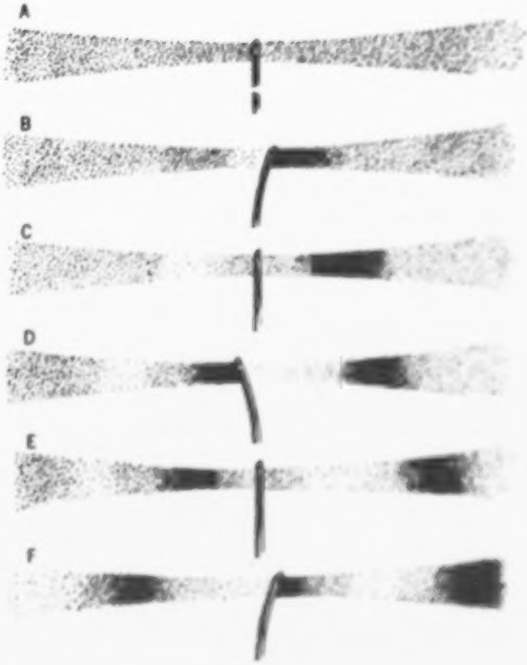


Figure 6–2. Sound wave produced by vibrating blade.

condensations (points of bunching) are shown by wave peaks. Each period of condensation of the air molecules develops one alternation (one-half cycle) on the graph. Also, the period of dispersion (rarefaction) of the air molecules provides the second alternation of the cycle. Hence, the three periods of condensation and rarefaction provide three cycles on the graph. This graph may be compared to the graph showing alternating current sine-wave development (fig. 4-17). In both graphs, you should note the + and − amplitude peaks from the horizontal (0) axis. In addition, each cycle represents an interval of time. In figure 6-1, each alternation is 1/800 of a second and the cycle requires 1/400 of a second (2.5 milliseconds). Thus, during each second, there are 400 sound wave cycles. (REMEMBER: Frequency is the term used to indicate the number of cycles per second.)

Complex Sounds. Complex sounds consist of two or more simple sounds, each having its own frequency and amplitude. Most sound sources in telephony do not produce sounds of the simple form represented by the sine wave seen in figure 6-1. The variations of the voice are of considerable importance in telephony, for any part of the telephone system which suppresses or distorts them makes the transmitting voice less intelligible.

We have mentioned frequency and amplitude of sound. These are the two most important qualities of sound from the standpoint of voice communication. Speech frequency is determined mostly by the speed of vibration of the speaker's vocal cords. Frequency determines the pitch (the highness or lowness) of a sound. The sound of a siren starts at a low frequency, goes to a high frequency, and ends at a low frequency. The human ear can detect sounds from about 20 cycles per second to about 20,000 cycles per second. Most speech requires only the frequencies between 200 and 3,000 cycles per second. In contrast, amplitude of sound is closely related to loudness. It is determined largely by the power used in speaking.

Sound Conversion. You have seen that the speech sound waves are converted into electrical waves by the transmitter. The electric current corresponds in waveform and frequency to the inducing sound waves. The electrical waves are carried over wire to the receiver of the listener's telephone. The receiver converts the electrical waves back into sound waves which again correspond in waveform and frequency to the original sound waves.

Why are frequency and amplitude important to a telephone system technician? Answer: The telephone circuits that you maintain and repair must transmit enough sound frequencies to make speech understandable. The sound amplitude at the receiver must be great enough to be heard. Poor solder connections reduce amplitude. Wrong sizes of certain components or faulty components can reduce frequencies and amplitudes to such an extent that speech is not understandable. The part of the telephone system, then, that sets up and controls the frequencies and amplitude in the circuits during a telephone conversation is the telephone for which you are responsible.

Exercises (046):

1. What does the movement of air pressure waves produce?

2. What is the period of reduced pressure in a wave called?

3. What do air pressure waves moving through a physical medium provide?

4. What graphically illustrates sound waves?

5. What are sounds called that have frequency and amplitude?

6. Name the two sound qualities most important to telephone technicians.

7. Give the lower and upper limits of the speech frequencies range.

8. What converts speech sound waves into electrical sine waves?

9. What component reforms electrical sine waves as speech sine waves?

10. What usually causes poor sound reproduction?

6-2. Telephone Components and Systems

There are many parts, actions, and circuits required for completing telephone calls. For example, there are the telephone set network, the ringer and ringer circuit, the transmit circuit, and the receiver circuit. The two telephone systems are the local and common battery systems. In this volume, we are only reviewing the principles for sample units, circuits, and systems. Greater detail about each will be in the later volumes.

047. Match telephone components with operational principles.

A modern telephone is shown in figure 6-3 and some of the major components are identified.

Telephone Components. A telephone's major components are:

a. The handset. The transmitter, the receiver, and the handhold for this unit are identified in the figure.

b. Handset cord. This cord extends from the handset to the circuitry in the telephone housing. Only a portion of this cord is illustrated in the figure. The cord generally has either three or four conductors which connect the receiver and transmitter to the circuits in the telephone housing.

c. Housing assembly. This assembly supports the dial assembly (which is illustrated), the hookswitch, an induction coil, capacitors, and ringer (all of which are not visible).

d. Deskstand cord (mounting cord). This cord extends rom the circuitry of the telephone housing to the connecting block (not a part of the telephone). The telephone circuit then extends to the protector block and to the outside lines and cables. This mounting cord also usually has three or more conductors, depending on the system and the type of telephone circuits used.

Figure 6-4 shows a cutaway view of a transmitter inclosed within a handset. The ribbed diaphragm moves in response to the speaker's voice and, in turn, changes the pressure on the carbon granules in the cup. As a result, the current for the associated telephone circuit varies in amount. The current variation matches the sound wave frequency, shape, and amplitude. Figure 6-5 shows the sound waves graphically above the man speaking into a transmitter and then above the transmission line is the graphic representation of the electric current (waves). By comparing the sound waves and electric current graphs, you can see that they are very similar in amplitude, shape, and frequency.

NOTE: The acoustic resistance, membrane, interconnecting carbon cup contacts, and back and cup chambers (fig. 6-4) are designed to provide maximum conversion efficiency for the transmitter. They reduce or eliminate noises developed at the side or back of the transmitter from being converted to current.

Figure 6-5 also shows the sound waves at the receiver graphically to indicate that the sound that the man listening at the receiving end hears is like that produced by the speaker.

Figure 6-6 pictures the modern receiver unit that provides the electric current to sound wave conversion. The magnet permanently pulls the diaphragm so that it forms a slight dish. The changing current in the conductors and the terminal plate, caused by the speaker's voice, pulls the diaphragm further into the pole piece-coil area or allows the dish to be reduced slightly. These changes in diaphragm position generate the sound that is heard by the person holding the receiver.

The varistor shunts unwanted high voltage away from the diaphragm-pole piece-coil area, thereby protecting the receiver and the ears of the person using it.

Exercises (047):

1. Place the letter before the telephone principle statement of column B in the blank for the telephone component of column A to which it relates. Each letter may be used only once.

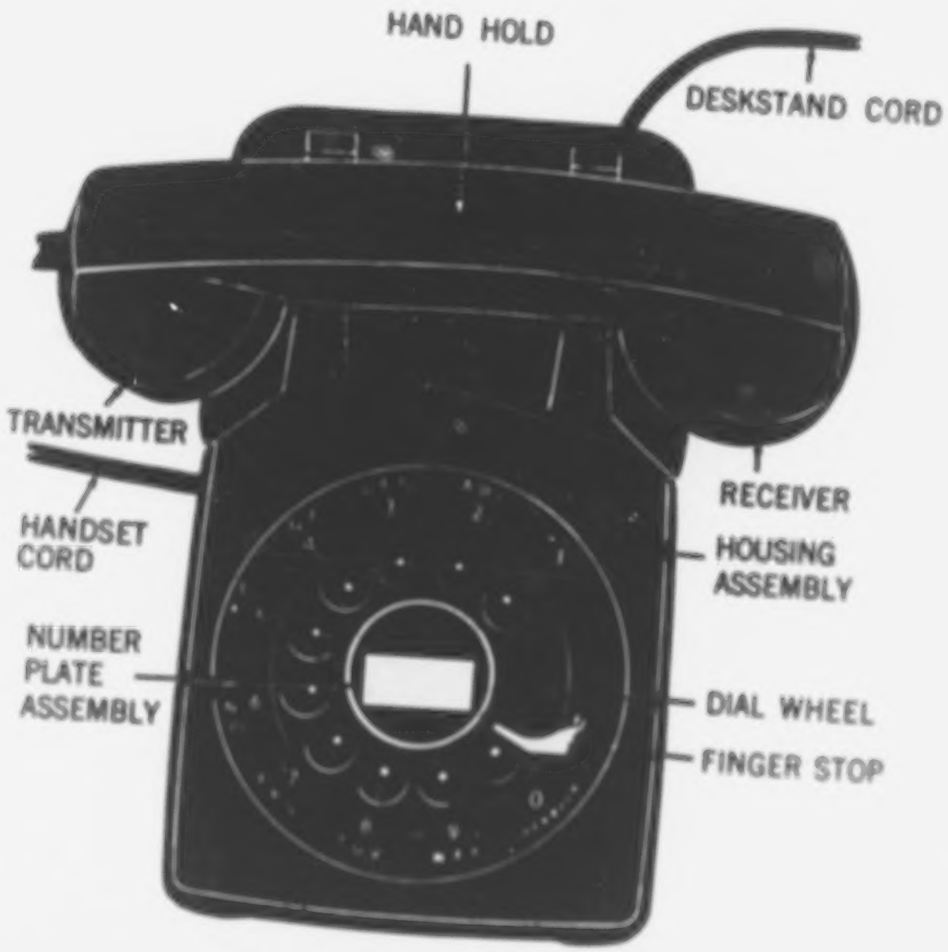

HAND HOLD
DESKSTAND CORD
TRANSMITTER
RECEIVER
HANDSET CORD
HOUSING ASSEMBLY
NUMBER PLATE ASSEMBLY
DIAL WHEEL
FINGER STOP

Figure 6-3. Typical table model telephone.

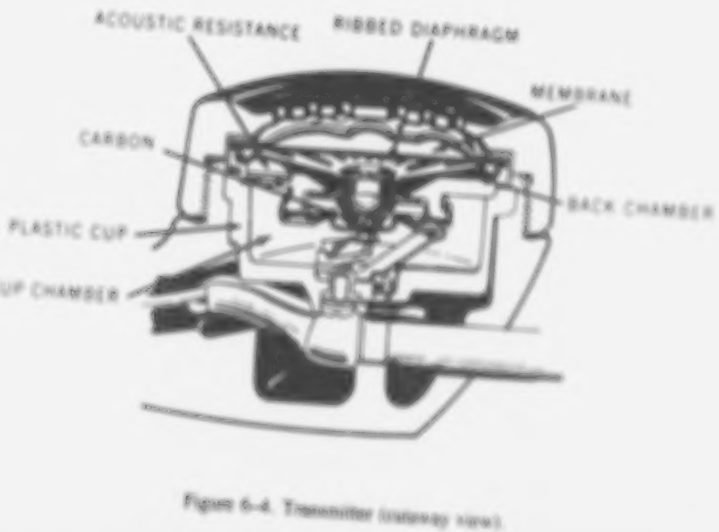

ACOUSTIC RESISTANCE
RIBBED DIAPHRAGM
MEMBRANE
CARBON
BACK CHAMBER
PLASTIC CUP
CUP CHAMBER

Figure 6-4. Transmitter (cutaway view).

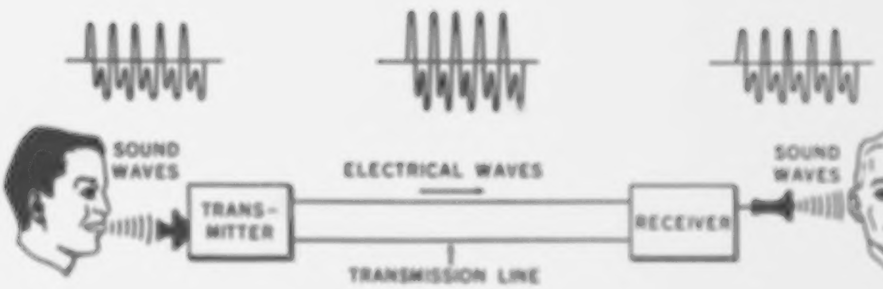


Figure 6-5. Telephone system function.

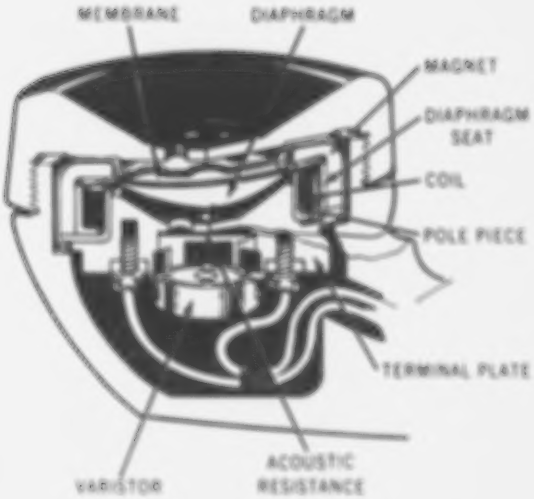


Figure 6-6. Modern receiver unit.

Column A

___ (1) Handset cord.
___ (2) Mounting cord.
___ (3) Transmitter diaphragm.
___ (4) Transmitter carbon granules.
___ (5) Transmitter acoustic resistance.
___ (6) Receiver diaphragm.
___ (7) Receiver magnet.

Column B

a. Reduces background noises.
b. Shunts unwanted voltage.
c. Generates speech sine wave.
d. Controls pressure on carbon granules.
e. Attaches telephone to connecting block.
f. Interconnects transmitter, receiver, and telephone network.
g. Changes sound to electricity.
h. Strengthens electrical signal effects for sound reproduction.

048. Using figure 6-9, name four components for a local battery system and specify characteristics to be noted.

Local-Battery Telephone System. The telephone battery was originally placed on the telephone instrument, as shown in figure 6-7. Note that each unit in this transmitter-receiver circuit is labeled and indicated by its standard symbol. This local-battery circuit was the granddaddy of the modern telephone. By connecting this telephone through a single line to another identical unit, conversation was carried from one point to another. This circuitry, however, did leave much to be desired.

One of the first improvements made to the local-battery system was to increase the effectiveness of the telephone over greater distances. When the set consisted of a receiver, battery, and transmitter connected in series, there were a number of losses in the circuit. Also, the resistance changes caused by variations in transmitter resistance were so small, compared with the total line resistance, that little receiver function resulted. The small current change did not produce enough difference in the magnetic field strength for the receiver to produce appreciable sounds.

Thomas Edison helped to correct the poor reception condition by installing an induction coil in the telephone coil so that the original (primary) transmitter current would flow only a short distance (see fig. 6-8). Thus, a change in transmitter resistance could create a relatively large change in the resistance of the primary circuit. This basic arrangement allowed battery current to flow through the

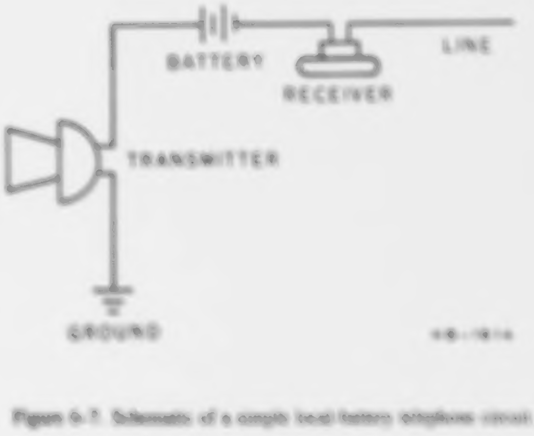


Figure 6-7. Schematic of a simple local-battery telephone circuit.

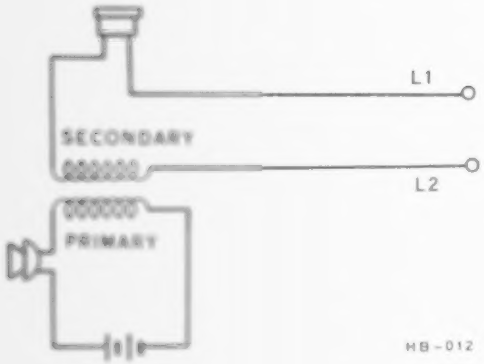


Figure 6-8. Basic primary and secondary circuit schematic diagram.

transmitter, the primary winding of the induction coil, and back to the battery, as shown also in figure 6-8. You can see that a change in the transmitter resistance could cause a large current change in the primary circuit. Then, with the transmitter operating, a relatively large voltage was induced in the secondary winding of the induction coil, and a greater difference in line current was available to produce receiver action.

The coil shown in figure 6-8 is basically a transformer. Therefore, the voltage induced in the secondary circuit is determined by the coil design. That is, the type of core, turns ratio, etc., all have a bearing on the amount of induced voltage. This type of induction coil is the very thing that gave the early telephone the needed power for transmitting at greater distances. Not only was the induction coil used in early telephones, but it is still used today in most of our modern telephones. Of course, it has had many refinements but it is still based on the same principles as those of the early telephone.

Comparing the simple circuit of figure 6-7 with the circuit of figure 6-9, we see that additional units were added to the simple circuit as refinements. Such units as a push-type switch, a ringer, and a hand generator were added to the circuit. These devices enabled a person at either end to signal another party.

Note in figure 6-9 that each telephone is powered by a battery that is connected in series with the transmitter and the primary winding of the induction coil. Also, note the push-to-talk switch located in each primary circuit just below the transmitter. This switch saves battery current because it opens the primary circuit during the time that sound is being received.

While there are only two telephones shown in figure 6-9, it is possible to connect several to a telephone line in a local battery system. Of course, when several telephones are connected to the same pair of telephone lines, a coded ringing system has been used. This is necessary because the operation of any one of the hand generators on the line will operate the ringers on all of the telephones.

Sidetone is the effect of hearing your own voice in the telephone receiver as you talk into the transmitter. The sidetone in a circuit such as that shown in figure 6-9 would be rather loud, because both telephone receivers are connected in a series circuit along with the secondary windings of both induction coils and the connecting telephone line. The voice current produced in this series circuit by a person speaking into the transmitter of either telephone passes through both receivers and is reproduced as a sound wave of speech in each one. Therefore, the persons using these telephones would hear their own voices reproduced in their own receivers.

Let's summarize a few points about the local-battery system. The term "local" means that the sources of electrical energy for the transmitters and for signaling are a part of the telephone subset at each individual telephone station. A local battery supplies the current for the transmitter circuit, and a hand generator or magneto supplies the current for signaling. The local-battery telephone subset is actually a self-powered unit since it requires no power from the central office for operation. Therefore, it can be used in conjunction with another local-battery telephone without being connected to a central office.

Exercises (048):

1. Identify the power supply for the transmitter circuit of figure 6-9.

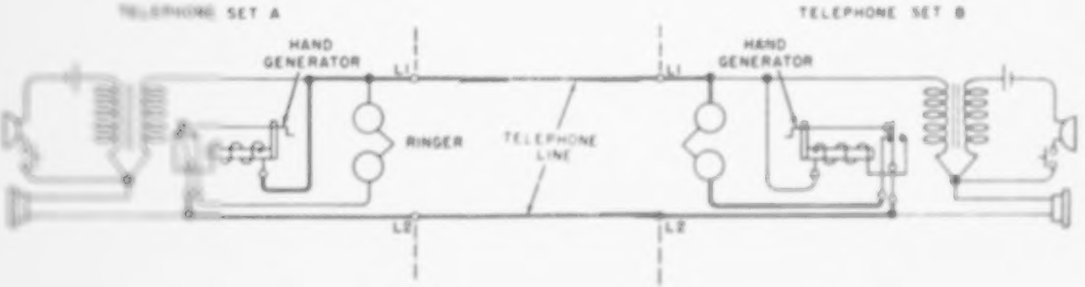


Figure 6-9. Signaling circuit of two local-battery telephone sets.

2. What component at each telephone set of figure 6-9 improved the efficiency of the system by its transformer action?

3. Identify the two units required in a local-battery telephone for its signaling circuit.

4. What telephone feature was improved by installation of the induction coil?

5. Name the effect that allows the speaker at the telephone to hear his or her own voice.

049. Name an undesirable telephone response and the procedure used to correct it.

In the telephone system shown in figure 6-9, the voice current in the telephone set of the speaker is greater than the voice current in the set of the listener. The reason is that the resistance of the telephone line opposes the voice currents, reducing their value before they reach the receiving end of the circuit. In addition, the voice current in the secondary winding is increased by the transformer action of the induction coil. This increased voice current, passing through the receiver of the speaker, further increases its output of sidetone.

The sidetone in a telephone should be at a level that promotes normal conversation. That is, you should hear your own voice in the telephone receiver with about the same volume as you hear it when having a normal conversation with someone. If the sidetone is completely eliminated from a telephone, the user then tends to shout just the same as a person who is hard of hearing. When the sidetone is too loud in a telephone set, it is undesirable for several reasons. First, speakers will lower their voices when they hears their voices loudly in their own receiver. This reduction of sound input to the transmitter reduces the voice current output, which in turn reduces the current in the receiver of the distant telephone set. Second, when the sidetone is too loud, it tends to lessen the sensitiveness of the ear of the speaker to the more feeble voice current from the distant telephone set. Third, when a telephone set has too much sidetone, the local room noise is picked up by the transmitter and is heard by the listener along with the voice of the distant speaker. These noises, reproduced in the local telephone receiver, distract the listener and reduce the intelligibility of the words received from the distant station. This effect is particularly objectionable when the telephone is used in usually noisy locations. It should be apparent from the previous explanation that sidetone must be controlled in the telephone set. It must not be completely eliminated because that would be just as bad as having too much sidetone. The circuits used to reduce sidetone are called antisidetone circuits. Although there are many and various types of antisidetone circuits used in modern telephony, we will consider only one circuit.

The circuit illustrated in figure 6-10 represents a ocal-battery telephone with an autotransformer type induction coil. Note that the primary winding of the induction coil is located between terminals 2 and 3—the secondary includes all three windings from terminal 1 to terminal 4. When current is on the increase in the primary circuit, as shown by the arrow in the figure, a voltage is induced in the secondary from terminals 1 to 4. At the instant when terminal 1 of the secondary is negative and terminal 4 is positive, electrons move from terminal 1, through the line circuit, the distant telephone, and back through the other side of the line circuit to capacitor C_2. If you will notice, positive is applied to the other side of capacitor C_2 from terminal 4. Thus, current flows from the secondary winding through the receiver of the distant telephone. It does not flow through the receiver from terminal X to terminal 3, because both of these terminals are of equal but opposite potential at the same time. Furthermore, during an alternation in the opposite direction, both of these potentials also cancel. Thus, the antisidetone circuit holds sidetone to a minimum during transmission.

We mentioned earlier that there should be some sidetone to promote normal conversation over the telephone. If the antisidetone circuits just described were perfectly balanced or a given frequency, they would probably eliminate most of the sidetone at that one frequency. For frequencies other than the one where balance is obtained, the circuit is partially unbalanced. Therefore, when the various frequencies of the audio spectrum are applied to the telephone circuitry, some sidetone is heard in the receiver. The components of the modern telephone are designed and constructed in such a manner as to produce the proper amount of antisidetone. This is assuming, however, that the telephone system and circuitry are maintained in proper order.

Exercises (049):

1. What sound factor handicaps the telephone user?

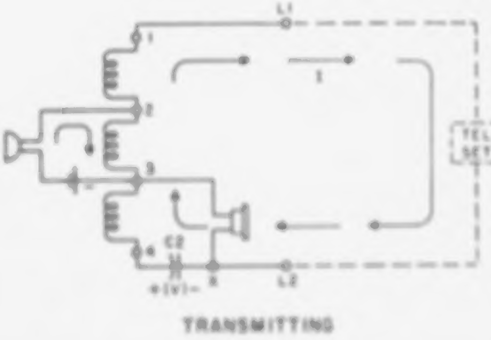


Figure 6-10. Antisidetone action.

2. Name the circuit used to reduce the objectional sidetone feedback.

3. Cite the process which limits the sidetone volume.

050. Compare common-battery and local-battery circuits.

The chief difference between common- and local-battery telephone systems is in the way the electrical energy is supplied for operation of the system. As explained previously, every telephone in a local-battery system operates on its own batteries. In a common-battery telephone system, a centrally located storage battery or power supply is used in place of the individual dry cells required at each telephone station in a local-battery system. This central power source (located at the central office) serves all of the telephone stations in a common-battery system.

Common-Battery Telephone System. Most of the telephone systems used in the United States are of the common-battery type. Furthermore, these common-battery systems may be divided into two basic categories: manual and automatic. With manual common-battery systems, the telephone calls are switched through manually by operators. With automatic systems, the calls are switched automatically by central office equipment in response to the numbers dialed on customers' telephones. It goes without saying that most of our systems are of the automatic (dial) type, since they offer more satisfactory service to the customer and the industry.

As you may have expected, many of the components of common-battery systems are identical with, or at least similar to, the corresponding local-battery components. Since the station equipment for both manual and automatic systems is covered in Volume 2 of the course, we will not discuss this equipment in this section. We will, however, discuss some of the general features of the common-battery systems.

Basic common-battery circuit. The basic circuit of a common-battery system is shown in figure 6-11. In this circuit, each telephone is equipped with an induction coil (I), a hookswitch (H), a capacitor (C), a ringer (RG), a transmitter, and a receiver. When the hookswitch is in the position shown, current flows from the switchboard battery through telephone line (L1), the primary winding of induction coil (I), the hookswitch, the transmitter, and the line L2 back to the switchboard battery. With the circuit in this condition, sound waves entering the transmitter varies the line current from the telephone to the central office. Furthermore, if the telephone sets are connected through the switchboard, the sound waves entering the transmitter of either telephone will be heard in the receiver of the other telephone set. The circuitry shown in figure 6-11 may be considered in three parts: the primary, or transmitter, circuit; the secondary, or receiver, circuit; and the ringing circuit.

a. Primary circuit. As explained in the previous paragraph, the primary circuit consists of the transmitter, the hookswitch, the primary winding of the induction coil, and the circuitry to terminals L1 and L2. The hookswitch closes this circuit whenever the receiver is lifted from its hook or cradle, as when the user lifts it to either answer or make a telephone call. When the user places the receiver back on its hook or cradle, the hookswitch opens the primary circuit, disconnecting it from the central office batter.

b. Secondary circuit. As shown in figure 6-11, the secondary circuit consists of the receiver connected in series with the secondary winding of the induction coil. As was explained for the local-battery system, variable DC in the primary winding of the induction coil induces an alternating current in the secondary winding and receiver. Thus, when either transmitter is spoken into in the system shown in figure 6-11, the sound is heard in the receivers of both telephones. Of course, in modern telephone systems, antisidetone circuitry is used to control the level at which the speakers hear their own voices in the receiver.

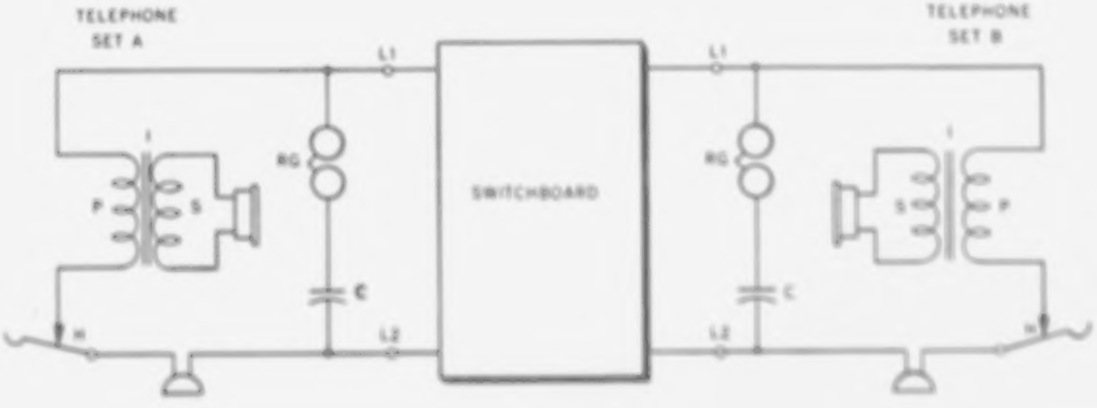


Figure 6-11. Basic circuit of common-battery telephone system.

c. Ringer circuit. In figure 6-11, notice that when the hookswitch is open, the primary circuit is disconnected from the switchboard battery. In other words, the telephone primary circuit from L1 to L2 is open. The ringer circuit, however, through ringer RG and capacitor C, is still a complete path for central office ringing current. Therefore, when ringing current from the switchboard is applied to terminals L1 and L2 via the telephone line, it passes through capacitor C and ringer RG to ring the called telephone. It should be noted that capacitor C will not pass direct current—therefore, it prevents the ringer RG from shorting the switchboard battery. This is important in common-battery telephony, because without capacitor C, the telephone ringer would be a continuous drain on the switchboard battery.

Signaling the switchboard. As illustrated in figure 6-11, there is no hand generator in the common-battery telephone set. In common-battery telephony it is not necessary to use an AC ringing current to signal the telephone office. Since lifting the receiver from its cradle allows the hookswitch to complete a circuit to the central office battery, a light connected in series with this circuit at the switchboard will illuminate whenever the receiver is lifted. Thus, the operator, at a manual common-battery switchboard, is signaled by the lighting of a lamp whenever a customer lifts his or her telephone receiver from its cradle.

With the automatic common-battery system (dial telephony), removal of the receiver from its cradle allows the hookswitch to complete a circuit to the central office battery through a line relay in the switching equipment. The operation of this relay connects the calling telephone through to the dial switching equipment. Thus, when customers lift their receivers, they are automatically connected through to the central office. They are then informed of their connections by the reception of dial tone in their receivers.

Exercises (050):

In the blank before the given statements, place an LB if the information applies to the local-battery telephone system and a CB if it pertains to the common-battery telephone system. Some statements may require both entries.

____ 1. The power supply is at the central office.
____ 2. The primary circuit consists of the telephone set hookswitch, transmitter and induction coil winding, and of switchboard devices.
____ 3. The hookswitch is series-connected with the transmitter.
____ 4. It consists of manual and dial exchanges.
____ 5. The telephone set has a hand generator.
____ 6. The power supply is in the telephone.
____ 7. The ringer is connected parallel to the telephone line and telephone set induction coil.
____ 8. The secondary circuit consists of the telephone set induction coil winding and receiver and switchboard devices.
____ 9. The telephone set(s) has supervision lamps.
____ 10. A lifted handset is followed by dial tone.

Glossary

Adapter—A device which is designed to complete connections between jacks, plugs, or receptacles by means other than those originally intended.

Alinement—The process of adjusting a circuit so that it will be responsive to a desired frequency or range of frequencies. Also, the adjustment procedure for components of a system so that their functions are synchronized.

Alligator Clip—Long, narrow spring clip with meshing jaws, primarily used with test leads for making temporary connections.

Amplification—Increase of magnitude in a signal from one point to another. It may be expressed as a ratio, or by extension of the term, in decibels.

Amplified Back Bias—Voltage developed across a fast time-constant circuit within an amplifier stage and fed back into a preceding stage.

Amplifier Classes—The circuit conditions that provide a specific bias for controlling the circuit current has resulted in the term ''class'' for amplifiers. Among the classes are A, AB, B, and C.

Anode—Positive electrode toward which electrons and negative ions are drawn.

Antiresonant Circuit—Parallel-resonant circuit.

Antisidetone—Arrangement of a telephone circuit where a small amount of power from the transmitting circuit is returned to the associated receiver.

Arcing—Spark jumping as can be seen at motor brushes or switch contacts.

Astable Multivibrator—A circuit that can switch rapidly from one status to another. Also spoken of as free running.

A-Supply—A voltage (power) supply which is of lower rating than the B-supply. It is used with electronic circuits.

Audio—Frequency that can normally be heard. Audio frequencies range from 20 to 20,000 cycles per second.

Automatic Switching—Connections that are made by using remotely controlled switches.

B-Battery—DC voltage supply for plate and screen grid electrodes.

Back Electromotive Force—Voltage developed in an inductive circuit by a changing current. The polarity of the induced voltage is opposite the applied voltage.

Base—The center semiconductor region of a double junction transistor. It is comparable to the grid of an electron tube.

Battery—Series of cells which produce electric current from chemical elements.

Bias—Electrical, mechanical, or magnetic force which is applied to a relay, vacuum tube, or other device, for the purpose of establishing a reference level for the operation of the device.

Binding Post—Terminal for connecting a conductor.

Bistable Multivibrator—A circuit which requires two input pulses to complete a cycle.

Bleeder—A resistor connected to improve voltage regulation, to remove the charge for a capacitor, or to protect equipment from excessive voltage after the load is removed.

Blocking Capacitor—Capacitor which limits low-frequency current without materially affecting the high-frequency current.

Bridge Circuit—Device which is used to measure electrical opposition by comparing a known circuit with the unknown.

Bridge Rectifier—Rectifier which has four elements arranged to provide full-wave rectification of alternating current.

Bucking Voltage—Opposing voltage.

Buffer Amplifier—A circuit designed to isolate a preceding circuit from the following circuit.

Bypass Filter—A circuit which provides a low attenuation shunt around some equipment devices.

Cable—An assembly of one or more conductors included within a protective sheath, thus permitting use of the conductors separately or in groups. Cable may be suspended by poles or towers (aerial) or installed underground (buried).

Calibration—Process of comparing an instrument with a standard to determine its accuracy or to devise a correct scale.

Capacitive Reactance—Opposition offered to alternating current by capacitance, expressed in ohms.

Capacitive Coupling—Association of two or more circuits through use of capacitance.

Carrier—High-frequency current superimposed on a voice current and on which additional frequencies can be modulated. Provides for the transmission of more than one type of intelligence simultaneously.

Cascade Amplifier—A circuit with several stages in which the output of one is fed into the input of a second.

Cathode Follower—An electronic circuit in which the output load is connected to the cathode circuit.

Classification System—Using a common qualifying base to arrange groups. Also, the groups are arranged to form a specific scheme.

Classified—A designation for official information which is to be protected in the interest of the Nation's defense.

Collector—The component of a transistor that compares to the plate of an electron tube.

Composite Cable—Cable in which conductors of different gages or types are combined within one sheath.

Confidential—Classification authorized for defense information or material which, if disclosed, is prejudicial to the defense interests of the Nation.

Continuity—The presence of a complete electrical circuit.

Corrosion—Eating away (dissolution) of metal by acid type chemicals.

Coulomb's Law—A law which states that the force between unlike charges is an attraction, between like charges a repulsion.

Coupling—Association of two circuits so that electrical energy may be transferred from one to the other.

Dead—Having no connection to any source of voltage.

Detector—Device which uses a carrier current while controlling a lower frequency unit.

Dial Pulse Springs—A pair of normally closed springs of a dial assembly, which is opened and closed by a pulse cam. The number of times that they open corresponds to the digit dialed.

Dial Shunt Springs—Set of contact springs of a dial assembly which shunt the receiver and transmitter of a telephone set whenever the dial is off normal (operated). Shunting of the receiver prevents pulse clicks from being heard during dialing while shunting of the transmitter prevents a variable resistance from affecting the generated pulses of the dial in the line loop.

Dial Switching Center—Communication building where automatic telephone and teletypewriter equipment is placed which connects two or more users together for communication purposes.

Diode—A device which changes alternating current into a pulsating direct current. Also called a rectifier.

Electronic—Work down by the movement of electrons.

Emitter—A transistor electrode from which the carriers depart.

Equipotential—Having the same potential at all points.

Feedback—Returning a fraction of the output signal to the circuit input.

Fixed Bias—Voltage of a constant value.

Flags—Code words, nicknames, and short titles for special subjects.

Flux—Term used to designate collectively all the electric or magnetic lines of force in a region.

Four-Wire—A two-way circuit using two paths arranged so that the communication currents are transmitted in one direction on only one path and transmitted in the opposite direction on the other path. The circuit arrangement may or may not include four wires.

Frequency—Number of electrical changes in a period of time.

High Resistance Junction—Union of conductors which is faulty, thus reducing the circuit current.

Hole—A mobile vacancy in the electronic structure of a transistor which acts as the positive point in the device.

Hydrometer—Float and marked container used in measuring specific gravity of a storage battery electrolyte.

Impedance—Total opposition to alternating current.

Inductance—The property of an electrical circuit which provides an opposing voltage to current changes, either in the circuit itself or in a neighboring circuit.

Inductive Coupling—Association of one circuit with another by means of inductance that is common or mutual to both.

Infinity—Having a resistance that is too great to measure.

Insulate—To separate from other conductors with a high-resistance material.

Interlock—A circuit in which one action cannot begin until one or more other actions have occurred. The interlocking action is generally obtained with relays.

Interrupter—Magnetically operated device for opening and closing an electric circuit rapidly and periodically.

IR Drop—Voltage drop across a resistor produced by current in the resistor.

Jack—Stationary part of a circuit connector.

Jumper—Short length of conductor used to connect terminals or used to connect around a break in a circuit. It is usually a temporary connection.

Kc—One thousand cycles per second (kilocycle).

Kirchoff's Laws—The sum of the current flowing to a given point in a circuit is equal to the sum of the current leaving that point. Also, the algebraic sum of the voltage drops in any closed loop of a circuit is equal to the algebraic sum of the electromotive forces in that circuit.

Lead—A wire to or from a circuit element.

Legend—Symbols or other data placed near a diagram to assist in determining the proper interpretation.

Lenz' Law—Current induced in a circuit as a result of its motion in a magnetic field is in such a direction as to exert an opposing force to the motion.

Linear—Having an output which varies in direct propotion to the input.

Line Balance—Matching impedance, equaling the impedance of the line at all frequencies, when terminating a two-wire line.

Loading—Connecting a power-consuming device to a circuit.

Loading—Insertion of reactance in a circuit for the purpose of improving its transmission characteristics in a given frequency band.

Locking—Keeping a device operating following the opening of the originating circuit. The term "hold" is also used to identify this second operating circuit.

Loop—A closed electrical circuit.

Loop Pulsing—Regular, momentary interruptions of the direct current in a closed electrical circuit.

Low-Pass Filter—Arrangement of components which passes all frequencies below a specified frequency with little or no loss but discriminates against any higher frequency.

Main Distributing Frame—Unit used for connecting the outside telephone lines to the switching center equipment. It also supports protective devices and functions as a test point.

Manning Document—Official paper showing all authorized positions for an organization.

Mc—One million cycles per second (megacycle).

Milli—One thousandth of a unit.

Monitor—Checking tne performance of a device, unit, or system by examining a sampling of the output.

Multiple—Connected in parallel.

Mutilation—Process of making a document unrecognizable and preventing its information from being reconstructed.

Mutual Induction—Inducing a voltage into one circuit from a neighboring circuit that is magnetically coupled with it.

Node—Zero point; for instance, an electrical point which has no current has been referred to as a current node.

Ohm's Law—E = IR, or I = E/R, or R = E/I.

Ohmmeter—Instrument for measuring resistance in an electrical circuit.

Open Circuit—A circuit which is not complete.

Open-Circuit Voltage—Voltage at circuit terminals when no appreciable current is in the circuit.

Patch—To connect circuits together temporarily by means of a cord with plugs, which is known as a patch cord.

Pawl—A device designed to fit into notches on its mating device.

Plant—The installed facilities which provide communications by electronic means.

Plug—Removable part of a circuit connector.

Polar Relay—A device that has a permanent magnet that centers the armature. The armature movement is determined by the direction of current in the windings.

Polarity—Condition in an electrical circuit by which the direction of the flow of current can be determined.

Potential—Difference in voltage between two points in an electrical circuit.

Potentiometer (POTS)—A three-terminal resistor which has one or more sliding contacts and thus functions as an adjustable voltage divider.

Preoperational—Before telephone equipment is "cut over."

Preventive Maintenance—Care of equipment that prevents future troubles.

Primary—First.

Primed—Act of making a device ready to operate.

Probe—Test lead used for checking electrical circuits.

Pulsing Relay—Device which reacts rapidly when there is a sudden change in its operating circuit.

Pulse Repeater—A device which receives pulses and reflects them into a second circuit.

Punching—Metal stampling designed to permit a connection to a conductor by means of solder.

RC Coupling—Placing resistors and capacitors in a particular arrangement so that they form a connection between two circuits.

Reciprocal—Method for determining resistance in a parallel circuit.

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Regenerative—Process by which a part of the power in the output circuit of an amplifying device is returned to the input circuit so that the initial power is increased.

Repeating Coil—A device, such as a transformer, which receives signals from one circuit and retransmits them to another circuit.

Residual—Magnetism which remains in a unit after removal of the magnetizing force. Also the name for a screw that is placed between relay armature and coil core which prevents residual magnetism from holding the armature opeated after the operating circuit is opened.

Resistance—Opposition which a device or material offers to current in an electrical circuit.

Resonant Frequency—The frequency at which the inductive reactance is equal to the capacitive reactance.

Ringdown—Circuit signaling where the signaling and supervision is controlled by a ringing current.

Secret—Information or material which, if disclosed, could result in serious damage to the Nation. For example, the release of information that shows the location of troops who are engaged in war.

Sensitive—All classified information is sensitive. Unclassified information, which reveals classified plans when used with other information, is also sensitive.

Series-Resonant Circuit—A circuit which has the power source in series with capacitance and inductance whose reactances cancel each other at the applied frequency.

Short Circuit—Low-resistance connection between two points, usually accidental. It results in excessive current which may damage the equipment.

Shunt—Two or more electrical devices connected so that the current may divide between them.

Slow-Operated Relay—A relay designed to act slowly following completion of its operating circuit.

Slow-Releasing Relay—A relay having a time delay in which there is an appreciable delay between the opening of the operating circuit and the release of the armature.

Sneak Current—Current which, while not particularly excessive, is above the normal specification for the equipment circuit. As a result it can produce heat damage to the components.

Solder—Alloy of lead and tin used in making circuit connections.

Specifications—Prepared engineering information for telephone equipment.

Spring Pileup—The assembly of all contact springs which are operated by an armature.

Static Electricity—Electricity that is on an object and which normally has no way to leave it. When a second object is brought near, electrons jump between the two.

Telephone Tapping—Connecting to a telephone circuit so that information can be withdrawn. For our purpose, this act is illegal.

Teletype—Transmitting system which uses a keyboard for sending and receiving typewritten messages.

Terminal—Final device or station in a system.

Termmination (4-Wire)—Connecting a load to a 4-wire line circuit.

Thermistor—An electronic device which changes resistance with a change in temperature.

Top Secret—Information or material which, if disclosed, could result in exceptionally grave damage to the Nation. If a disclosure would result in an armed attack on the Nation, for example, the information would be classified Top Secret.

Transient—Instantaneous surge of voltage which results from a circuit change.

Trunk—Communications channel between two offices or between groups of equipment within the same office.

Tuned—Adjusted to operate at a specific frequency. It also describes a circuit that consists of inductance and capacitance which can be adjusted for resonance at a desired frequency.

Unclassified—Information which need not be protected but may be subject to security safeguards.

Unidirectional—Effective in one direction only.

Varistor—Device whose resistance lowers when the voltage increases. It is used to shunt harmful voltage away from circuit components.

Vault (Cable)—A building repository where communications cable is spliced together.

Verify—To insure that the connections or actions are correct.

Vernier—Device applied to the graduated scale on many instruments which permits accurate adjustment or which enables the repairer to make a more precise reading.

Voltage—Term used to identify electrical pressure.

Voltage Divider—Resistor or resistors which provide adjustment by which a parallel connected load can receive a required voltage value.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

001 – 1. (1) c.
(2) f.
(3) a.
(4) e.
(5) d.

002 – 1. Telephone subsets, key telephone systems, key switch systems, and associated equipment.
002 – 2. Subset cords, ringers, induction coils, handsets, and dials.
002 – 3. Telephone units and system power units.
002 – 4. The 5-level specialist may be required to supervise an installation crew and as a result observe and inspect the crew's work.
002 – 5. By looking at trouble records to denote recurring troubles and analyzing difficult troubles so that the troublesome components can be repaired, replaced, or modified.

003 – 1. 3c.
003 – 2. The 5-level specialist can do all parts of a task rapidly and accurately and can explain why the procedure must be done and why the specific tasks for that procedure are needed.
003 – 3. 4c.
003 – 4. Volume 4, Chapter 4.
003 – 5. Chapter 3, Volume 4.
003 – 6. TO 31W2–10–15.

004 – 1. An E–3, E–4, or E–5.
004 – 2. No. The career field chart of text figure 1-1 shows that an E–8 airman is a superintendent (AFSC 36199 or 36299 on the career field chart).
004 – 3. By answering the learning objective exercises, doing the Volume Review Exercise, and taking the Course Examination.
004 – 4. Through self-study and the learning-by-doing concept.
004 – 5. The JPG is a more detailed listing of job tasks than is the STS.
004 – 6. The airman must have completed a CDC and have shown proficiency in the job.
004 – 7. A supervisor's recommendation.
004 – 8. Passing the SKT and a PFE.
004 – 9. The CDC.
004 – 10. You should accurately apply your job related knowledges (for example, knowledge of the proper operating procedures for key systems equipment and test equipment), use technical orders, and be patient.

CHAPTER 2

005 – 1. Management is responsible for identifying and evaluating problems, for developing methods to eliminate delays and failures, for knowing the workers and organizing them to get the best operation, and for planning and coordinating so the established goals are reached.
005 – 2. Management controls by planning and coordinating, by organizing the people and the resources, by making decisions, and by assigning responsibility and giving authority to those having the responsibility.
005 – 3. Money, materiel (tools, telephone and test equipment, military vehicles, etc.), and worker's time.
005 – 4. Workers need respect, recognition, and responsibility with authority.
005 – 5. Management duties are primarily those of setting goals, supervision, and coordination; whereas, the worker duties involve technical skills and are primarily manual labor.

006 – 1. Plan facilities and service, study regulations and monitor compliance with these policies, and verify and correlate programs.
006 – 2. Develop a base wire communications plan.
006 – 3. Order equipment and follow up the order, and oversee its maintenance.

007 – 1. Orient new crewmembers, assign crewmembers, determine workers' proficiency, and solve personnel problems.

008 – 1. Place the organizational chart where you can see and describe it, list the new worker's duties, arrange for his or her tools and working equipment, and allow adequate time for a thorough orientation.
008 – 2. During a new worker's orientation, discuss the individual's background (education and training and work experience), explain the organizational structure and the new person's duties, emphasize safety rules and work restrictions, and tell him or her about his fellow workers and how their and his or her duties correlate.
008 – 3. A new worker's work methods and questions.

009 – 1. Personnel available and qualifications of personnel, urgency of the job, job tasks, and area of the job.
009 – 2. Job knowledge and task experience, licenses each holds, and daily appointments.
009 – 3. The urgency of the job and the sequence of the tasks.

010 – 1. Work standards.
010 – 2. Observation, evaluation, making recommendations, showing examples, and followup.

011 – 1. Installation and maintenance.
011 – 2. Observation.
011 – 3. Tools, equipment facilities, and trainers.

012 – 1. Lecture, discussion, demonstration, and performance.
012 – 2. Guide and advise trainees without being domineering, tell them what is expected and show how each step fits into the total picture, and emphasize accuracy and safety.
012 – 3. Observe worker's performance for good and weak techniques, ask questions, and make recommendations.
012 – 4. AF Form 623.

013 – 1. Field visits and questionnaires.
013 – 2. A review of the AF Forms 623, a check of the trainee's progress toward completion of the CDC, and an observation of the trainee's work performance.

014 – 1. Define the problem, determine goals (objectives) and actions for overcoming the problem, and decide the action to use.
014 – 2. Were the instructions clear, are there family problems or health problems that could affect the worker's performance, or was the worker using incorrect procedures.

014 – 3. Coordinate with all associates and have all the facts.
014 – 4. Provide written instructions for each job a worker must perform.
014 – 5. Follow it up by monitoring the specialist's work again.

015 – 1. AFM 30-3 and AFR 35-1.

016 – 1. To become more proficient or to renew proficiency.
016 – 2. Cross-training.

017 – 1. Telephone equipment and *Air Force* vehicles.
017 – 2. Determining and ordering equipment necessary for a proposed system, developing conduits for the installation, scheduling the work, making operational check of completed installation, and completing installation records.

018 – 1. Order replacement tools and test equipment, get test equipment checked on schedule, emphasize safety and use of technical orders, and be responsible for conduct of crew and for care of the assigned equipment.
018 – 2. The crew chief should insure that the required tools, test equipment, directives, and spare parts are on the truck.

019 – 1. (1) a.
(2) a.
(3) a and b.
(4) a and b.
(5) a and b.
(6) a and b.
(7) a and b.
(8) a and b.
(9) a.
(10) a and b.

020 – 1. Give a signal and use a spotter.
020 – 2. Sound the horn, drive slowly, and stop when a schoolbus is stopped.
020 – 3. Stay in the proper lane and note clearance and load limitations.
020 – 4. Reduce speed and apply brakes gradually.
020 – 5. Drive the specified rate, do not cut in and out of lanes, do not make a U-turn, and never cross the center median or double stripes in the center of the roadway.
020 – 6. Before changing lanes to pass, look carefully in front, to the side, and rear; don't speed up as a driver attempts to pass; and never pass a car when ascending a hill.
020 – 7. Give the proper signal.
020 – 8. Reduce your speed so that you are in full control of the vehicle, and give pedestrians the right-of-way.
020 – 9. One car length for every 10 miles of speed.
020 – 10. Don't drink while driving nor drive while drinking.
020 – 11. Observe the speed limit; use low beams when meeting cars and while following a car; if you must stop, use flasher lamps and place flares 100 feet ahead.

021 – 1. Turn front wheels into the curb, set the handbrake, stop the engine, and place the gearshift in reverse.
021 – 2. Exit on the curb side.
021 – 3. Give the proper signal and constantly observe the traffic for clearance to enter the flow.

022 – 1. Operate the lights, directional signals, wipers, and brakes; adjust the mirrors; clear away obstructions to your view; and check the tires.
022 – 2. Steering irregularities, unusual braking action, and abnormal noises and odors.
022 – 3. Refuel and clean the vehicle.
022 – 4. Checking and testing tire tread and air pressure, checking battery condition, caring for the cooling system, making minor adjustments, and removing a faulty part and reinstalling its replacement.

CHAPTER 3

023 – 1. a. AFR 205-1.
b. DOD 5200.1-R.
c. AFR 205-1.
023 – 2. Unclassified.
023 – 3. Unclassified.
023 – 4. Top Secret.

024 – 1. Introduction of new equipment and deficiencies in installed equipment.
024 – 2. Personnel shortages and important visitors.
024 – 3. Change in unit organizational structure.

025 – 1. Keep only classified material in the file and insure that the storage unit is properly locked.
025 – 2. You must have a need for using the material and must complete the record form correctly.
025 – 3. That the destruction is sufficient to preclude recognition or reconstruction of the material.

026 – 1. By messenger and by encryption.
026 – 2. Secret material would be placed in a double, opaque envelope and be transported by registered mail.
026 – 3. Confidential message.

027 – 1. A long-distance official incoming call may be from an unknown caller and when identified as urgent may cause the receiving individual to violate security, if he or she fails to use good judgement.
027 – 2. The first mistake was unnecessarily disclosing classified information over the telephone.
027 – 3. When dealing with official information and when in doubt of its sensitivity, don't discuss it over the telephone.
027 – 4. No. You should only inform your caller that you cannot give this information over the telephone.
027 – 5. No. It just can't be done successfully.

028 – 1. Communications security, information security, and physical security.
028 – 2. Protection.
028 – 3. The planning, developmental, doing, and critique and reporting phases.
028 – 4. Operations, communications, and routine functions.
028 – 5. Sudden changes in plans and publicity about these changes are two improper OPSEC acts. Discussing organizational activities over the telephone or with a family or friendly civilian who have no need-to-know is likewise an improper OPSEC act. Requesting command maintenance assistance by using a project nickname and using the same term in documenting and reporting the maintenance results are also improper actions.

CHAPTER 4

029 – 1. It has an attraction for electrons.
029 – 2. Unlike charges of electricity attract each other.
029 – 3. Like charges of electricity repel each other.
029 – 4. $I = E/R$.

030 – 1. Energized.
030 – 2. Prepare the circuit for relay PL1.
030 – 3. Approximately negative 24 volts DC should be noted at TB terminal 28.
030 – 4. Between terminals B and C are connected a fixed resistor and a capacitor.
030 – 5. Included in the operating circuit for relay PL1 are a ground, the terminal for contact #7 of relay A, contacts 17 and 3 of relay A, contacts #7 and 3 of relay B, the relay windings of PL1, and battery.

031 – 1. Battery B1 provides the –24 volts DC to the relays.
031 – 2. Contacts of the second PICKUP and CUTOFF keys are strapped together.
031 – 3. Visual signaling, DC1 voice signaling, 2-way voice circuits, and radio telephone circuit.
031 – 4. Station line.
031 – 5. Station line and voice signaling.
031 – 6. DT1.

032 – 1. Relay PL1 would have .040 ampere or 40 milliamperes.
032 – 2. 1,000 ohms.
032 – 3. 24 volts.

033 – 1. $\frac{R_1}{R_2} = \frac{R_3}{R_4}$ or $\frac{1,000}{10,000} = \frac{500}{5,000} = \frac{1}{10}$

Also $\frac{R_1}{R_3} = \frac{R_2}{R_4}$ or $\frac{1,000}{500} = \frac{10,000}{5,000} = \frac{2}{1}$

033 – 2. Branch 1 total resistance of 150 ohms causes 0.12 ampere for the branch. Hence, the voltage drop for R_1 is 12 volts. The 225 ohms resistance of branch 2 permits 0.080 ampere in the branch. Voltage drop at R_3, then, is likewise 12 volts. Points A and B are, therefore, 12 volts negative in respect to the positive side of the battery.

034 – 1. Parallel resistors having 12 and 36 ohms provide a circuit resistance of 9 ohms.
034 – 2. 2 amperes.
034 – 3. 8 volts.

035 – 1. Alternating current generation, self-induction, and mutual induction.
035 – 2. The effects produced by the magnetic field of the primary moving into a secondary winding.
035 – 3. By magnetically linking the primary circuit of a unit to the secondary unit.
035 – 4. There would be an automatic increase in current.
035 – 5. A magnetic field, a looped conductor, and motion.
035 – 6. Brushes and sliprings.

036 – 1. F.
036 – 2. F.
036 – 3. F.
036 – 4. T.
036 – 5. T.

037 – 1. Open.
037 – 2. Intermittent short.
037 – 3. Note the trouble symptom, inspect the equipment, and analyze the circuits.
037 – 4. Trace the applicable circuit schematics and check equipment test points while using test equipment and following a logical sequence of steps.

038 – 1. (1) c, d, and e.
(2) a and b.
(3) e.
(4) e.
(5) b.

039 – 1. The capacitor at terminal A.
039 – 2. Shorted contacts for the HOLD key or open contacts of the 1ST PICKUP key.
039 – 3. A short circuit of the R2/R4 branch or an open circuit in the R1/R3 branch.
039 – 4. A short circuit (possibly at C4).

CHAPTER 5

040 – 1. T.
040 – 2. F.
040 – 3. T.
040 – 4. T.
040 – 5. F.

041 – 1. Figure 5-2.
041 – 2. Figure 5-3.
041 – 3. Figures 5-2 and 5-3.
041 – 4. Figures 5-2 and 5-3.
041 – 5. Figures 5-2 and 5-3.
041 – 6. Figure 5-3.

042 – 1. To amplify.
042 – 2. Common-base, common-emitter, and common-collector.

043 – 1. (1) b.
(2) d.
(3) a.
(4) b.
(5) a and c.
(6) c.
(7) b.
(8) b and d.
(9) a, b, and d.
(10) c.

044 – 1. S and C.
044 – 2. C.
044 – 3. S.
044 – 4. S and C.
044 – 5. S.
044 – 6. C.
044 – 7. S and C.
044 – 8. S.
044 – 9. S.
044 – 10. S and C.

045 – 1. A change in resistance of R_1 or R_2.
045 – 2. A reduction in resistance either at C_2 or at R_2.

CHAPTER 6

046 – 1. Sound.
046 – 2. Rarefaction.
046 – 3. Sound transmission.
046 – 4. Sine waves.
046 – 5. Complex.
046 – 6. Frequency and amplitude.
046 – 7. 200 and 3000.
046 – 8. The transmitter.
046 – 9. Receiver.
046 – 10. Poor solder connections and wrong and faulty components.

047 – 1. (1) f.
(2) e.
(3) d.
(4) g.
(5) a.
(6) c.
(7) b.

048 – 1. A low-voltage local battery.
048 – 2. An induction coil.
048 – 3. A signal developing generator and a signal receiving ringer.
048 – 4. Telephone reception.
048 – 5. Sidetone.
049 – 1. Abnormal sidetone volume.
049 – 2. Antisidetone.
049 – 3. Magnetic induction.

050 – 1. CB.
050 – 2. CB.
050 – 3. LB and CB.
050 – 4. CB.
050 – 5. LB.
050 – 6. LB.
050 – 7. LB and CB.
050 – 8. LB.
050 – 9. CB.
050 – 10. CB.

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S T O P - 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

36254 01 23

INTRODUCTION TO THE CAREER FIELD

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet .
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

Note to Student: Consider all choices carefully and select the best answer to each question.

1. (001) The Airman Wire Communications Systems Maintenance Career Field does not include installation and repair methods for

    a. electronic switching equipment.
    b. telephones and key systems equipment.
    c. missile communications control equipment.
    d. teletypewriter, teleautograph, and cryptographic equipment.

2. (002) The duties and responsibilities which are listed in AFM 39-1 for telephone equipment installation and repair specialists are called

    a. job proficiency guides.
    b. specialty descriptions.
    c. job computer printouts.
    d. specialty training standards.

3. (002) Refer to text figure 1-2. Which of the following responsibilities includes the preparation of installation plans and worksheets?

    a. Maintenance of key telephone and key switch installations.
    b. Repair of telephone subsets.
    c. Installation of key telephone systems.
    d. Installation of telephone subsets.

4. (003) Which Special Training Standard (STS) code indicates that the worker can explain the relationship of basic facts and can state general principles relative to the subject?

    a. a.
    b. b.
    c. A.
    d. B.

5. (003) If a 5-level specialist is expected to be competent at performing a given task, how should the item be coded in the 5-level column of the STS?

    a. 2.
    b. 3.
    c. a.
    d. B.

6. (003) Refer to text figure 1-4. What is the study reference for the 1A1 key system?

    a. TO 31W2-10-15.
    b. TO 31W1-102.
    c. AFM 39-1.
    d. AFM 50-23.

7. (004) What is the purpose of the on-the-job training (OJT) program?

a. Identify previously learned malpractices of airmen.
b. Increase airmen's knowledge and skill.
c. Reform airmen's habitual practices.
d. Eliminate errors of airmen.

8. (004) While on OJT, which of the following documents serves as a guide for your skill training?

a. STS.
b. PFE.
c. CDC.
d. SKT.

9. (004) Select the two requirements for promotion to E-7.

a. Be certified as highly proficient and receive a score of 88 on the CE.
b. Be certified as qualified and pass the CE.
c. Pass the SKT and PFE.
d. Pass the STS and PFE.

10. (005) Counseling and disciplining of people is a part of management's

a. resource.
b. decision.
c. organization.
d. routine schedule.

11. (005) In addition to established goals, scheduled work, and assignment of people, organization efficiency could be achieved through

a. reduced time standards.
b. delegation of jobs indiscriminately.
c. job evaluation.
d. limited purchases.

12. (005) As a manager, select the basic resources for which you are responsible.

a. Materiel, money, and personnel.
b. Programs, organizations, and supplies.
c. Methods, programs, and supplies.
d. Equipment, materiel, assets, and time.

13. (006) Telephone communications system modification or expansion are programmed

a. by customers.
b. by quality control.
c. with a multiyear base wire communications plan.
d. with an annual base wire communications plan.

14. (006) Which of the following permits the Air Force to provide reliable service at the lowest possible cost?

a. Job rotation. c. Cost negotiation.
b. Personnel limitation. d. Management centralization.

15. (007) Select a responsibility of a team chief.

a. Analyze work motions and train his workers.
b. Make schedules and advise workers.
c. Replace equipment, revise records, and eliminate priorities.
d. Analyze specifications, repair circuits, and correct documentation.

16. (008) When preparing to orient a new worker, you should

a. plan your introduction.
b. reorganize your crew around the new worker.
c. assign a subordinate to the task.
d. make a list of common crew problems for the subordinate.

17. (008) Which of the following methods should the supervisor use with new workers during the orientation followup?

a. Observe their work methods closely.
b. Assign difficult tasks immediately.
c. Follow up verbal instructions with written rules.
d. All of the above.

18. (009) To complete the assigned jobs efficiently and consistently a crew chief must

a. give all commands aggressively.
b. assign difficult tasks routinely.
c. follow up verbal directions with written directives.
d. learn the tasks for each job and determine subordinate's qualifications.

19. (010) To insure that work standards are met, which one of the following must be performed by a telephone maintenance team chief?

a. Reconstruct defective wire spring relays.
b. Develop the maintenance regulations.
c. Analyze engineering specifications.
d. Observe the work procedures.

20. (010) Who rates the maintenance performance of each team member?

a. Squadron commander. c. Quality control evaluator.
b. Resident school evaluator. d. Workcenter supervisor.

21. (011) What is the probable cause for a crewmember to maladjust a wire spring relay?

a. Improper tools were provided.
b. Personnel received improper training.
c. Wire spring contacts are undependable.
d. Wire springs were of the wrong design.

22. (012) Which document shows that you have reached the required task proficiency?

a. WAPS.
b. SKT.
c. JPG.
d. PFE.

23. (013) Select the additional training evaluation conducted by Air Training Command (ATC) to determine the adequacy of the formal schools.

a. Quality control.
b. Supervisory.
c. Commander.
d. Field.

24. (014) After making a decision on a worker's problem, you should follow it up by

a. monitoring the airman's work.
b. justifying your decision.
c. consulting the worker.
d. validating the facts.

25. (015) A Personnel Action Request is a form used when

a. requisitioning furniture.
b. classifying airmen.
c. scheduling and assigning crews.
d. preparing a new worker orientation.

26. (016) Select the terms which applies to the temporary assignment of an airman trained in 6A system maintenance to repairing 302 system equipment.

a. Reclassification.
b. Justification.-
c. Monitoring.
d. Rotation.

27. (016) To obtain a broad understanding of each AFS, a telephone plant maintenance superintendent must

a. have a 362X1 special training survey.
b. have the 362X4 occupational survey.
c. receive an augmentee evaluation.
d. be cross-trained.

28. (017) As an installation team chief, which one of the following is not your responsibility?

- a. Advise workers.
- b. Authorize changes to workcards.
- c. Rotate crewmembers.
- d. Record job results.

29. (018) An acceptable procedure for the proper care of test equipment at the workcenter is to

- a. schedule each test set for inspection every ninety days.
- b. set the rheostats at the lowest setting when beginning each test.
- c. turn the zeroing screw fully counterclockwise when beginning each test.
- d. observe safety relative to each unit and the certification termination date.

30. (019) Leased telephone equipment trouble calls are

- a. reported to the Air Force telephone control office.
- b. reported to the maintenance control function.
- c. cleared by the quality control function.
- d. cleared by Air Force workcenter personnel.

31. (019) Select the publication which outlines the maintenance of the telephone service records.

- a. AFM 100-22, Management of Base Communications Facilities and Services.
- b. AFM 100-20, Management of Electrical Record Communications.
- c. AFM 100-18, USAF Ground Communications Planning and Management.
- d. AFM 100-8, Programming and Management Telecommunications Requirements.

32. (020) Schools and playgrounds are great safety hazards, because

- a. traffic officers issue the most tickets there.
- b. traffic officers park most often there.
- c. children often run carelessly from them.
- d. children have excellent control of balls when throwing.

33. (020) At the moment that your vehicle begins to skid what should you do?

- a. Press the clutch and brake pedals down immediately.
- b. Turn the front wheels in the direction of the skid.
- c. Turn the front wheels in the opposite direction of the skid.
- d. Alternately press the clutch and brake pedals until the skid ceases.

34. (020) Refer to text table 2-1. How many feet does a car travel in 1 minute when its speed is 50 miles per hour?

a. 73.
b. 900.
c. 3,500.
d. 4,380.

35. (020) When approaching the crest of a hill, you should

a. accelerate rapidly.
b. shift to a lower gear.
c. reduce speed and keep to the curb side of the road.
d. shift to high gear and accelerate rapidly.

36. (021) Safe parking procedures include turning the wheels properly, setting the brakes, and

a. rapid acceleration when moving into the curb.
b. stopping the engine.
c. operating windshield wipers.
d. keeping a car length between vehicles.

37. (022) Before-operation service on a vehicle does not include the

a. inspection of oil filter.
b. checking of tires.
c. inspection of operational lights.
d. testing of brakes.

38. (022) Select the procedure which is a part of during-operation service.

a. Inspect the tires.
b. Adjust the engine's idle speed.
c. Observe the fuel level.
d. Listen to noises.

39. (022) Which procedure is not considered as preventive maintenance?

a. Check tire valve covers.
b. Inspect radiator fluid level.
c. Listen to unusual noises.
d. Replace vehicle fuses.

40. (023) Which regulation governs the Air Force information security program?

a. AFR 205-1.
b. AFR 205-27.
c. AFR 205-37.
d. AFR 205-57.

41. (023) Which of the following publications identifies a security publication used in the Air Force?

a. AFR 5-1.
b. TO 00-5-1.
c. TO 00-5-2.
d. DOD 5200.1-R.

42. (024) A defense department plans to send a reconnaisance plane over a specified location; this information is an example of

a. EEFI.
b. EFTO information.
c. OPSEC information.
d. FOR OFFICIAL USE ONLY type information.

43. (025) When you finish using a classified publication, you

a. may place it face down on the desk and cover it with unclassified documents.
b. must return it to the secure storage unit and sign the control record.
c. must return it to the secure storage unit and notify a security policeman.
d. may place in your desk and lock the drawer.

44. (025) When a classified document in _not_ in use, it must be

a. kept in storage files at security police headquarters.
b. kept in a locked storage unit with other classified documents.
c. enclosed within an opaque envelope and identified with a code.
d. enclosed within two opaque envelopes and stored at the crypto section.

45. (026) Which of the following means could you use to send an Air Force Secret document within the United States?

a. Electrical means.
b. Certified mail.
c. First class mail.
d. Registered mail.

46. (026) Top Secret information may be

a. transmitted by code.
b. sent by registered mail.
c. sent by certified mail.
d. sent in clear text electrically.

47. (027) Which one of the following is the most dangerous security factor?

a. Radio messages.
b. Deficient regulations.
c. Individual carelessness.
d. Electromagnetic equipment.

48. (028) What type security is involved when documenting maintenance actions?

a. OPSEC.
b. COMSEC.
c. TRANSEC.
d. Physical.

49. (028) Which one of the following is required from the individual with whom you are discussing classified information?

a. Need to know.
b. Awareness of the security regulations.
c. Clearance from the security officer.
d. Knowledge of the confidential activity code.

50. (029) An atom with more electrons than normal around the nucleus is

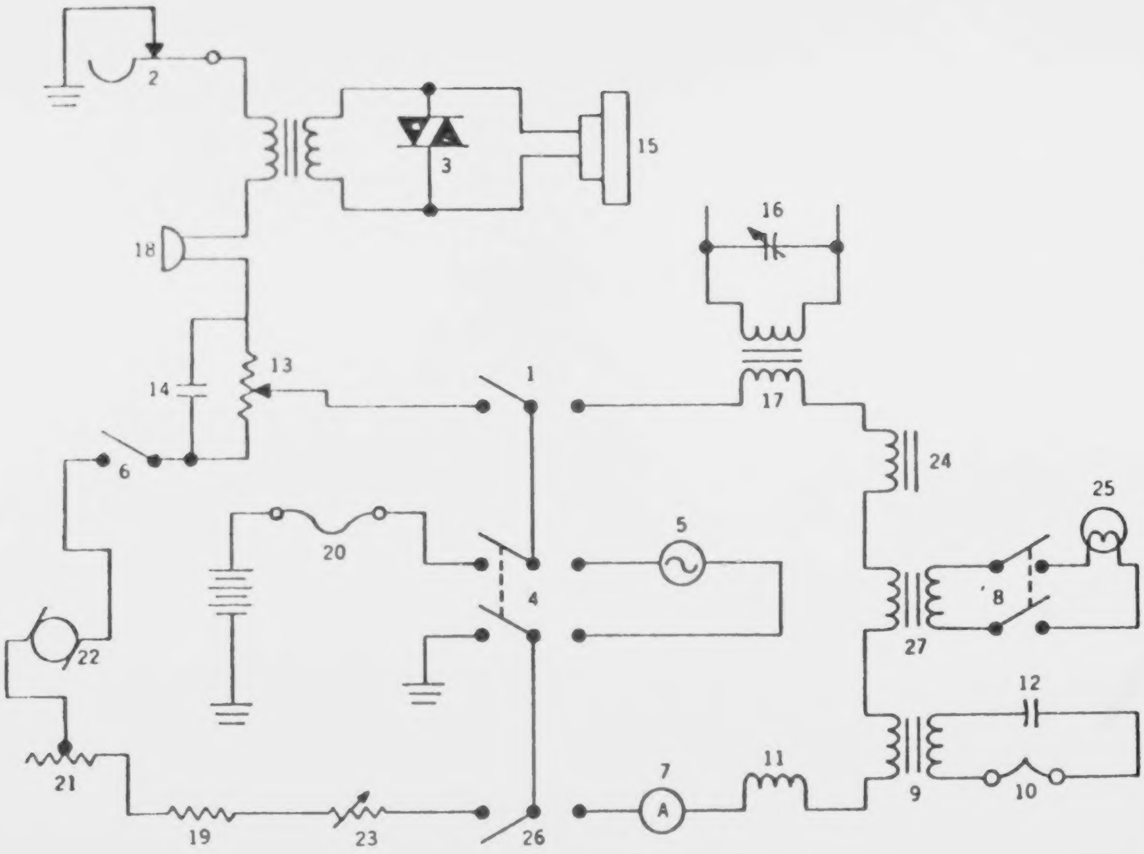
a. electrically neutral.
b. atomically neutral.
c. positively charged.
d. negatively charged.

51. (029) A basic electrical law is that unlike charges of electricity

a. seek positive electrical charges.
b. seek negative electrical charges.
c. attract each other.
d. repel each other.

52. (030) Refer to text figure 4-1. Name the symbols for the circuit devices connected between FL1 terminals C and A.

a. Relay winding and lamp.
b. Resistor and capacitor.
c. Relay winding and resistor.
d. Capacitor and rectifier.



VRE Figure 1

NOTE TO STUDENT: Refer to VRE Figure 1 and Text Figure 4-2 in answering questions 53 through 56.

53. (030) Which of the numbered symbols is for a single pole switch?

a. Number 1.	c. Number 6.
b. Number 4.	d. Number 8.

54. (030) Select the numbered symbol for the hookswitch.

a. Number 2.	c. Number 20.
b. Number 6.	d. Number 26.

55. (030) Which of the numbered symbols is for a rheostat?

a. Number 3.	c. Number 13.
b. Number 11.	d. Number 21.

56. (030) What is the number for the symbol of a telephone transmitter?

a. Number 10.	c. Number 18.
b. Number 15.	d. Number 22.

57. (031) Refer to text figure 4-5. Select the relay contacts which enable relay A to operate.

a. 11T and 12 of relay FL1.
b. 3 and 4T of relay B.
c. 2 and 1T of relay A.
d. 2 and 1T of relay B.

58. (031) Refer to text figure 4-4. How many one-way voice circuits are available to position 2 in the 302 system?

a. One.
b. Three.
c. Four.
d. Five.

59. (031) Refer to text figure 4-4. Identify the circuit which provides telephone connection for the weather bureau.

a. One-way voice circuit.
b. Radio-telephone circuit.
c. Visual signaling circuit.
d. Station line circuit.

60. (032) When two 10-ohm resistors are connected in parallel with a 24-volt batter, the total current flow in the circuit is

a. 5 amperes.
b. 4.8 amperes.
c. 2.0 amperes.
d. 1.2 amperes.

61. (032) The total current in a parallel circuit is

a. less than the current through any of the branches.
b. equal to the source voltage divided by the value of the smallest branch resistance.
c. equal to the source voltage divided by the sum of the resistance values.
d. equal to the sum of the currents through all of the branches.

62. (033) Refer to text figure 4-8. Which of the following conditions applies to a bridge circuit with resistors R1 - 20 ohms, R2 = 80 ohms, R3 = 30 ohms and R4 = 120 ohms?

a. The bridge is balanced.
b. The bridge will be balanced if the battery is replaced with a rectifier.
c. The bridge will be balanced when a galvanometer is connected between points A and B.
d. The bridge has a potential difference between points A and B.

63. (034) Refer to text figure 4-11. What is the total resistance for the circuit when R1 = 75 ohms, R2 = 20 ohms, R3 = 50 ohms, and R4 = 30 ohms?

a. 175 ohms.
b. 42 ohms.
c. 35 ohms.
d. 12 ohms.

64. (034) Refer to text figure 4-11. If the total current of the circuit is .005 ampere, what is the voltage drop at R_1?

a. 6 volts.	c. .015 volts.
b. 1.5 volts.	d. .01 volts.

65. (035) Name the process by which current in one loop of the primary winding induces voltage in loops of a secondary winding.

a. Self-induction.	c. Mutual reactance.
b. Mutual induction.	d. Conductive reactance.

66. (035) A coil in an alternating current (AC) circuit has a

a. frequency which will not vary.
b. potential of 90 amperes.
c. farad of reactance.
d. back EMF.

67. (035) Refer to text figure 4-15. If the coil has been replaced with an iron core coil, which of the following circuit conditions will occur?

a. The generator frequency will increase.
b. The generator voltage will increase.
c. Circuit impedance will increase.
d. Circuit current will increase.

68. (035) Refer to text figure 4-16. What type of current is present within the generator's windings?

a. DC only.	c. AC and DC.
b. AC only.	d. Undirectional.

69. (036) Which one of the following would you expect to find in a resonant AC series circuit?

a. Maximum current.	c. Minimum current.
b. Frequency rectification.	d. Zero voltage at the reactor.

70. (036) Of the listed current values, which is most likely to be found in a parallel-resonant electronic circuit?

a. 300 milliamperes.	c. 2 amperes.
b. 1 ampere.	d. 10 amperes.

71. (037) An open lamp should result in which of the following?

a. A blown circuit fuse.
b. A blown equipment power fuse.
c. Zero ohms resistance reading for PSM-6 ohmmeter.
d. Infinite resistance reading for PSM-6 ohmmeter.

72. (038) Name two electronic devices to inspect when you have a trouble symptom of "noisy circuit."

a. Fuse and ON lamp.
b. Inductor and capacitor.
c. Disciminator and ON-OFF switch.
d. Thermistor and resonant transformer.

73. (039) Refer to text figure 4-8. When R4 is open, which of the following conditions will result?

a. Current will increase in R1.
b. Resistance of R2 will increase.
c. R_T will increase.
d. E_T will decrease.

74. (039) Refer to text figure 4-8. When points A and B in the circuit are shorted, what is the current through resistor R2?

a. 2 amperes.
b. 3 amperes.
c. 4 amperes.
d. 5 amperes.

75. (040) Which one of the following is required for the operation of a solid state device?

a. 600-ohm tank circuit.
b. Thermistor.
c. Varistor.
d. Battery.

76. (040) What circuit condition results when you provide reverse bias to a PN Junction?

a. Current is increased.
b. Power source is shut off automatically.
c. Current is decreased.
d. Power source voltage is decreased.

77. (040) Current for a junction diode with reverse bias is measured in

a. amperes.
b. microvolts.
c. microamperes.
d. micromicrovolts.

78. (041) A device used in electronic gates because of its small size and requirement for a minimum of power is a

a. vacuum tube amplifier.
b. vacuum tube regulator.
c. transistor.
d. synchro motor.

79. (042) Which of the following terms describes the process in which an input signal to a transistor is connected to a larger output signal?

a. Amplification.
b. Distortion.
c. Oscillation.
d. Generation.

80. (043) Whicn of the following amplifiers has an inverted signal at the output from that at the input?

a. Common-emitter.
b. Emitter-follower.
c. Grounded-base.
d. Class B.

81. (043) Which amplifier conducts without interruption so that its output signal is linear?

a. Class C amplifier.
b. Class B amplifier.
c. Class A amplifier.
d. Class AB amplifier.

82. (043) A nonlinear output signal from a class A amplifier results from

a. changing the value of the stabilizing resistor.
b. stabilizing the collector supply voltage.
c. connecting two or more resistors as voltage dividers.
d. stabilizing the bias battery voltage.

83. (044) Which one of the following troubles would probably be observed during a visual inspection?

a. Open wire.
b. Low resistance resistor.
c. High tensioned relay spring.
d. Improperly gapped wire spring contact.

84. (044) Efficient repair of a 302 system is the result of using

a. test lamps with insulated high voltage test leads.
b. accurate analysis techniques and good trouble location procedures.
c. logical analysis methods and tone tests for low resistance components.
d. logical analysis methods and visual inspection for high resistance components.

85. (044) Which of the following trouble symptoms should you look for during a trouble check?

a. Abnormal operation.
b. Signal distortion.
c. Short circuit.
d. All of the above.

86. (045) What is a probable cause for a transistor having a distorted output signal?

a. Intermittent open emitter.
b. Open biasing resistor.
c. Grounded carbon blocks.
d. Blown fuse.

87. (046) What are the two important sound qualities considered by the telephone specialists?

a. Power supression and vibration distortion.
b. Voice complexity and molecular amplitude.
c. Time delay and pitch suppression.
d. Pitch and loudness.

88. (046) Name the telephone component which converts sound waves into electrical energy.

a. Thermistor.
b. Energizer.
c. Transmitter.
d. Transformer.

89. (047) Sound waves are converted to electrical waves by

a. carbon granules.
b. magnetic carbon button.
c. a lead disc in electrolyte.
d. a nonmagnetic coil of wire.

90. (047) Which one of the following operates the receiver diaphragm?

a. Electromagnetic attraction.
b. Electromechanical polarization.
c. Carbon button attached to the receiver diaphragm.
d. Thin metal disc oscillating in conjunction with stationary electromagnetic waves.

91. (048) The addition of a two-winding induction coil to the early local-battery telephone

a. provided the required circuitry for moving the battery to the switchboard.
b. permitted the use of a battery in the secondary circuit.
c. increased the transmitting power of the telephone.
d. decreased the telephone line resistance.

92. (048) Name the term for the sound of your own voice as you talk into the transmitter of the telephone.

a. Sidetone.
b. Distortion.
c. Excitation.
d. Hertz effect.

93. (048) The hand generator is used with each

a. battery-powered telephone.
b. common-battery telephone.
c. automatic-dial telephone.
d. local-battery telephone.

94. (049) Identify the telephone circuit that limits voice feedback and background noise.

a. Primary circuit.
b. Sidetone circuit.
c. Secondary circuit.
d. Antisidetone circuit.

95. (050) Select the telephone component which completes the circuit to the central office battery.

a. Hand generator.
b. Induction coil.
c. Hookswitch.
d. Transmitter.

96. (050) In common-battery telephones, the electrical energy used in voice transmission is supplied by

a. the telephone transmitter.
b. a battery at the central office.
c. a battery in each telephone set.
d. a generator in each telephone set.

97. (050) During voice transmission, the output of the transmitter used with the common-battery telephone would be classified as

a. pure direct current.
b. variable direct current.
c. pure alternating current.
d. variable alternating current.

98. (050) Refer to text figure 6-11. What is the purpose of capacitor C in the telephone circuit?

a. Function as a part of the antisidetone circuit.
b. Function as a part of the transmitting circuit.
c. Block DC from passing through the ringer.
d. Block AC from passing through the ringer.

99. (050) With a manual common-battery system, the telephone user signals the switchboard operator by

a. using his hand generator.
b. lifting the receiver from its cradle.
c. dialing zero on most telephone subsets.
d. lifting the receiver and using the hand generator.

100. (050) Refer to text figure 6-11. What happens when the receiver is placed on its hookswitch?

a. The induction coil secondary is connected to the line circuit.
b. The telephone ringer is disconnected from the line circuit.
c. The transmitter, battery, and receiver are connected to the line circuit.
d. The transmitter and induction coil primary are disconnected from the line circuit.

End of Exercise

ATC/ECI SURVEY

The remaining questions (125-135) are not part of the Volume Review Exercise (VRE). These questions are a voluntary ATC/ECI survey. Using a number 2 pencil, indiate what you consider to be the appropriate response to each survey question on your answer sheet (ECI Form 35), beginning with answer number 125. Do not respond to questions that do not apply to you. Your cooperation in completing this survey is greatly appreciated by ATC and ECI. (AUSCN 100)

PRIVACY ACT STATEMENT

A. Authority: 5 U.S. C. 301, Departmental Regulations

B. Principal Purpose: To gather preliminary data evaluating the the ATC/ECI Career Development Course (CDC) Program.

C. Routine Uses: Determine the requirement for comprehensive evaluations in support of CDC program improvement.

D. Whether Disclosure is Mandatory or Voluntary: Participation in this survey is entirely voluntary.

E. Effect on the Individual of not Providing Information: No adverse action will be taken agains any individual who elects not to participate in any or all parts of this survey.

QUESTIONS:

125. If you have contacted ECI for any reason during your enrollment, how would you describe the service provided to you?

a. Excellent.
b. Satisfactory.
c. Unsatisfactory.
d. Did not contact ECI.

126. My ECI course materials were received within a reasonable period of time.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

127. The condition of the course materials I received from ECI was:

a. A complete set of well-packaged materials.
b. An incomplete set of well-packaged material.
c. A complete set of poorly-packaged materials.
d. An incomplete set of poorly-packaged materials.

128. The reading level of the material in the course was too difficult for me.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

129. The technical material in course was too difficult for me at my present level of training.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

130. The illustrations in the course helped clarify the information for me.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

131. Approximately how much information in the course provides general information about your AFSC?

a. Between 80 and 99%. c. Between 40 and 59%.
b. Between 60 and 79%. d. Between 20 and 39%.

132. Approximately how much information in this course was current?

a. Between 80 and 99%. c. Between 40 and 59%.
b. Between 60 and 79%. d. Between 20 and 39%.

133. The format of the text (objective followed by narrative and exercises helped me study.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

134. The volume review exercise(s) helped me review information in the course.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

135. Check the rating which most nearly describes the usefulness of the information in this CDC in your upgrade training program.

a. Excellent.
b. Satisfactory.
c. Marginal.
d. Unsatisfactory.

NOTE: If you know this CDC contains outdated information or does not prove the knowledge that the current specialty training standard requires you to have for upgrade training, contact your OJT advisor and fill out an AF Form 1284, Training Quality Report.

STUDENT REQUEST FOR ASSISTANCE

PRIVACY ACT STATEMENT

AUTHORITY: 10 USC 8012 and EO 9397. **PRINCIPAL PURPOSES:** To provide student assistance as requested by individual students. **ROUTINE USES:** This form is shipped with ECI course package. It is utilized by the student, as needed, to place an inquiry with ECI. **DISCLOSURE:** Voluntary. The information requested on this form is needed for expeditious handling of the student's need. Failure to provide all information would result in slower action or inability to provide assistance to the student.

SECTION I: CORRECTED OR LATEST ENROLLMENT DATA: *(Mail to ECI, Gunter AFS AL 36118)*

1. THIS REQUEST CONCERNS COURSE (1 - 6)
2. TODAY'S DATE
3. ENROLLMENT DATE
4. AUTOVON NUMBER
5. SOCIAL SECURITY NUMBER (7 - 15) ☐☐☐ - ☐☐ - ☐☐☐☐
6. GRADE/RANK
7. NAME *(First initial, second initial, last name)* (17) (18) (19-32)
8. ADDRESS *(OJT Enrollees -- Address of unit training office with zip code. All others -- current mailing address with zip code.)* (33-53) (54-75)
9. NAME OF BASE OR INSTALLATION IF NOT SHOWN ABOVE
10. TEST CONTROL OFFICE ZIP CODE/SHRED (33 - 39)

SECTION II: REQUEST FOR MATERIALS, RECORDS, OR SERVICE

(Place an 'X' through number in box to left of service requested)

1 Request address change as indicated in Section I, Block 8.

2 Request Test Control Office change as indicated in Section I, Block 10.

3 Request name change/correction (Provide Old or Incorrect data)

4 Request Grade/Rank change/correction.

5 Correct SSAN. (List incorrect SSAN here) (Correct SSAN should be shown in Section I)

6 Extend course completion date. (Justify in REMARKS)

7 Request enrollment cancellation. (Justify in REMARKS)

8 Send VRE answer sheets for Vol(s): 1 2 3 4 5 6 7 8 9 Originals were: ☐ Not received ☐ Lost ☐ Misused

9 Send course materials. (Specify in REMARKS) ☐ Not received ☐ Lost ☐ Damaged

10 Course exam not yet received. Final VRE submitted for grading on ______________ (date).

11 Results for VRE Vol(s) 1 2 3 4 5 6 7 8 9 not yet received. Answer sheet(s) submitted ______________ (date).

12 Results for CE not yet received. Answer sheet submitted to ECI on ______________ (date).

13 Previous inquiry (☐ ECI Fm 17, ☐ Ltr, ☐ Msg) sent to ECI on ______________ (date).

14 Give instructional assistance as requested on reverse.

15 Other (Explain fully in REMARKS)

FOR ECI USE ONLY

16 G	33	
K	Vol 33 - 35	GR 36 - 38
M	33 - 34	35 - 40
N	33 - 35	
P	Vol 33 - 35	
	TC 36 - 37	38
	DOE 39 - 45	
Q	33 - 34 QQ	38 1
	MC 39 -42	

REMARKS *(Continue on Reverse)*

OJT STUDENTS must have their OJT Administrator certify this request.

ALL OTHER STUDENTS may certify their own requests.

I certify that the information on this form is accurate and that this request cannot be answered at this station. *(Signature)*

ECI FORM OCT 83 17 (PREVIOUS EDITIONS MAY BE USED)

SECTION III: REQUEST FOR INSTRUCTOR ASSISTANCE

NOTE: Questions or comments relating to the accuracy or currency of subject matter should be forwarded directly to preparing agency For an immediate response to these questions, call or write the course author directly, using the AUTOVON number or address in the preface of each volume. All other inquiries concerning the course should be forwarded to ECI.

VRE Item Questioned:

Course No ____________

Volume No ____________

VRE Form No ________

VRE Item No ________

Answer You Chose _______ (Letter)

Has VRE Answer Sheet been submitted for grading?

☐ Yes ☐ No

REFERENCE

(Textual reference for the answer I chose can be found as shown below)

In Volume No __________

On Page No ___________

In ☐ left ☐ right column

Lines ____ Through _____

MY QUESTION IS:

REMARKS

ADDITIONAL FORMS 17 available from trainers, OJT and Education Offices, and ECI. Course workbooks have a Form 17 printed on the last page.

36254 02 8012

CDC 36254

TELEPHONE EQUIPMENT INSTALLATION AND REPAIR SPECIALIST

(AFSC 36254)

Volume 2

Telephone Construction and Repair

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EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

THIS SECOND volume of Course 36254, Telephone Equipment Installation and Repair Specialist, continues with the common-battery telephone systems features. It reviews the basic principles of central office switching, the station equipment, and telephone records. In addition, the volume has information about maintenance and inspection, wire maintenance safety, and technical orders.

Direct your questions or comments relating to the accuracy or currency of this volume to 3750 TCHTG/TTKMS STOP 44, Sheppard AFB Texas 76311. If you need an immediate response, call AUTOVON 736-2088 between 0800 and 1600, Monday through Friday. *NOTE: Do not use the suggestion program to submit changes or corrections to this course.*

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to a Successful Course, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If this person can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 18 hours (6 points).

Material in this volume is technically accurate, adequate, and current as of April 1980.

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2 Station Equipment in Automatic Systems 6

3 Maintenance and Inspection System and Records 30

4 Wire Maintenance Safety 41

5 Technical Orders 48

Answers for Exercises 59

NOTE: In this volume, the subject matter is developed by a series of student-centered objectives. Each of these carries a three-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see whether your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Common-Battery System Features

AS A TELEPHONE equipment installation and repair specialist, as you already know, you must install, troubleshoot, and repair telephones and telephone circuits. To do this, you must understand the various telephone systems, circuits, and components. In Volume 1, we looked at the fundamentals of electricity and the telephone, the basic theory of telephone component operation, and the principles for local- and common-battery telephone systems. Volume 2 will relate telephone set components to the manual and automatic common-battery telephone systems and cover telephone station maintenance, troubleshooting and repair, and special tools and equipment you use to test components and circuits. This chapter briefly reviews the telephone set components and provides further details about common-battery systems and their advantages.

1-1. Telephone Set Component Review

This section reviews the transmitter, receiver, induction coil, and capacitors. We shall start with the transmitter because it is the unit that transforms the sound waves into electrical impulses. Secondly, we shall consider the receiver because it receives the electrical impulses and converts them to sound waves. Thirdly, we shall discuss the induction coil, which is used in conjunction with the transmitter and receiver. We shall discuss capacitors last because they may be used in conjunction with the other telephone components.

200. State how a typical telephone transmitter works and cite improvements that have been made on the earlier transmitters.

Transmitters. The vibration of the transmitter diaphragm varies the current through the transmitter according to the resistance within the carbon cup. With the development of handsets, a transmitter adaptable to different positions became a necessity. The carbon cup transmitter (fig. 1-1) was a dual improvement: it could be moved in any direction without carbon granules moving about in the cup, and the shape of the carbon chamber and position of the electrodes kept the carbon granules from packing together within the cup. This transmitter overcame many of the objections of previous transmitters, and its frequency response was much more uniform. In fact, the whole tranamitter is more efficient because of the improved devices such as contactors, insulators, and diaphragm. The diaphragm is now constructed of a thin aluminum alloy, supported by paper on the edges, with a silk, moisture-resistant membrane stretched across the front to protect the transmitter parts from the moisture of the speaker's breath. Because the modern transmitting unit has only a few parts and is assembled at the factory by stamping and pressing operations, it cannot be repaired by field forces. If the transmitter unit of a telephone is bad, it must be replaced.

One special-purpose transmitter we should mention is the differential transmitter which is worn directly in front of the speaker's lips. It is commonly called a noise-canceling transmitter, because noises entering from the side or back of the transmitter are canceled out, and only those noises that enter directly from the front are transmitted.

Most differential transmitters operate by equalizing the pressure exerted on the face of the diaphragm. Because of the structure of the transmitter and the arrangement of the acoustic openings and airspaces about the transmitter diaphragm, diaphragm motion resulting from distant sounds is practically zero. Side sounds cause almost no change in the resistance of the transmitter carbon granules and thus cause no perceptible change in the transmitting current.

Exercises (200):

1. How does the transmitter change sound to electric current?

2. List the three major transmitter components.

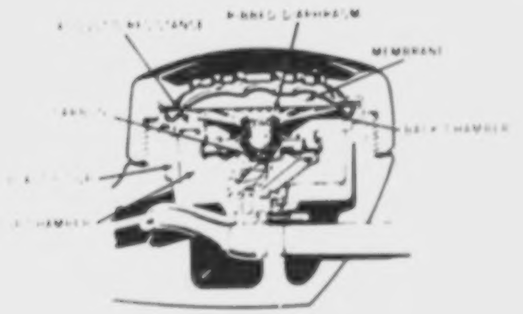


Figure 1-1. Modern telephone transmitter.

3. How has the diaphragm been improved?

4. What is the advantage of a differential transmitter?

201. State how a typical receiver operates and list five basic components.

Receivers. Receiver development has been a continuing development. Figure 1-2 shows the components of a receiver. The flat receiver unit in the handset is the result of recent telephone engineering. More effective sound characteristics are obtained with this receiver than were possible without the new magnet arrangement. The ring-shaped pole piece concentrates the magnetic lines of force near the diaphragm. You can see the position of the coil within the magnet. Note the screws that attach the conductors to the receiver terminal plate. The other components should be familiar to you.

The receiver principle is still the same—magnetic forces from an electric current create sound waves that match in shape the original sound waves striking the transmitter. The magnetic forces varying with the strength of the current in the coil (fig. 1-2). The magnetism strengthens or weakens the pull of the permanent magnet on the receiver diaphragm.

Exercises (201):

1. List five components of a telephone set receiver.

2. How does the receiver operate?

202. State how induction coils and capacitors are used.

Induction Coils. The induction coil is used in the modern telephone mainly to provide good transmission and reception and to reduce and control sidetone during transmission. As we mentioned in Volume 1, the early telephone induction coil used two windings, a primary and a secondary. In figure 1-3, note that the circuitry is built around a three-winding induction coil with a primary winding, a secondary winding, and a balancing (or tertiary) winding to provide the antisidetone effect. The induction coil is the heart of an antisidetone circuit. Remember: the current in the primary winding and transmitter induces voltage at the secondary. The current in the secondary also flows through the receiver. The antisidetone circuit will be explained in Chapter 2.

Telephones now have a network assembly that contains the induction coil, capacitor, resistor, etc., required for transmitting and receiving. Figure 1-4 shows a telephone set network.

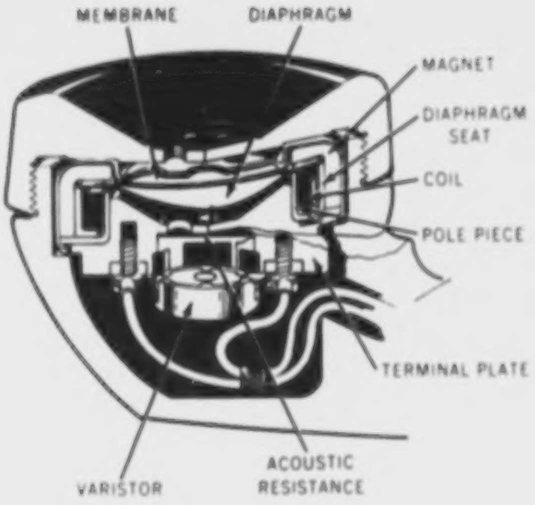


Figure 1-2. Modern telephone receiver.

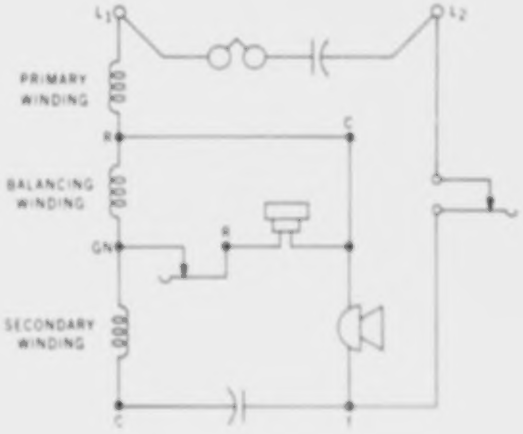


Figure 1-3. Antisidetone circuit schematic.

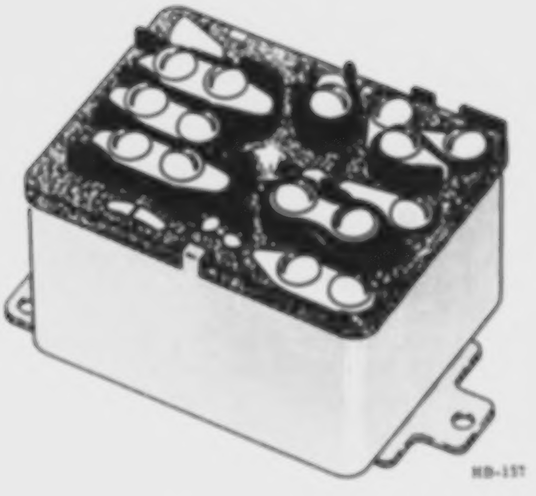


Figure 1-4. Typical telephone network.

Capacitors. Capacitors in telephones have several functions. In the modern common-battery telephone a capacitor is connected in series with the ringer to block the passage of dc current. In many telephones, a capacitor blocks the passage of dc current through the receiver. Capacitors with the required rating may be used to pass ringing currents and to reject voice frequencies. A capacitor used in conjunction with an induction coil, (fig. 1-3) helps to produce a strong transmitter output and aids in reducing sidetone.

Exercises (202):

1. What are the three induction coil windings?

2. Cite three induction coil uses.

3. List three functions of a telephone circuit capacitor.

4. Name two telephone set devices to which a capacitor is connected.

1-2. Common-Battery Telephone Systems

Shortly after local-battery telephone systems proved successful, telephone engineers realized that a central source of power could furnish more economical and more satisfactory service. All modern systems use a central office with either switchboards or switching equipment of some kind. The central office and switchboard operator are often called "central" or "operator." As few as three or as many as several hundred telephone stations may be connected by lines to a single central office. The size and extent of the system may vary, but each of the telephones in a system can contact the other stations in the system.

203. Name the units of a common-battery system, and cite its advantages.

Units. The telephone stations, switchboard, and connecting lines shown in figure 1-5 constitute a telephone system with a single central office. Such a telephone system with the central office and connected telephone stations may be the whole system, but it is frequently only a part of the system and is called a telephone exchange. The connection of two or more exchanges by trunks (fig. 1-6) is a common arrangement. For example, a large city normally has several exchanges, all connected by trunks. Although most telephones have dials, we shall discuss dial systems in Chapter 2.

Figure 1-7 is a block diagram of a typical common-battery telephone system without the switching equipment at the central office. It shows that the switchboard has jacks, plugs, signal lamps, a battery, and a ringing machine. Actually, the normal central office has the power equipment separated from the switchboard and this power equipment also supplies the switching equipment its direct current and ringing current. In addition, the power equipment includes a generating unit for keeping the battery charged.

The switchboard signal lamps operate automatically when the subset receiver is removed from the hookswitch. This refinement, along with others, allows the common-battery switchboard to handle a large volume of traffic. Such operating speed and efficiency would not be possible with a local-battery system.

The operating qualities of common-battery and local-battery systems are similar. Excellent communications can be attained with either system when it is used in its proper place. Each telephone system, therefore, performs an important communications function for the armed services.

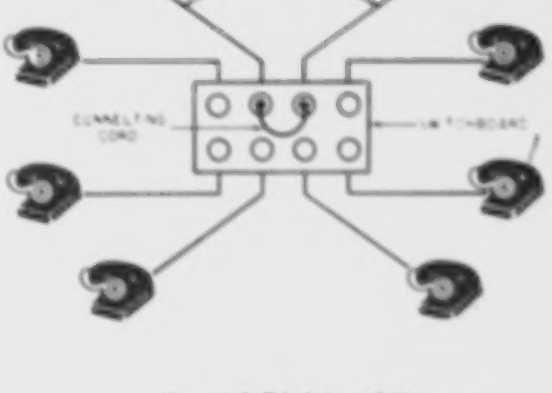


Figure 1-5. Telephone exchange.

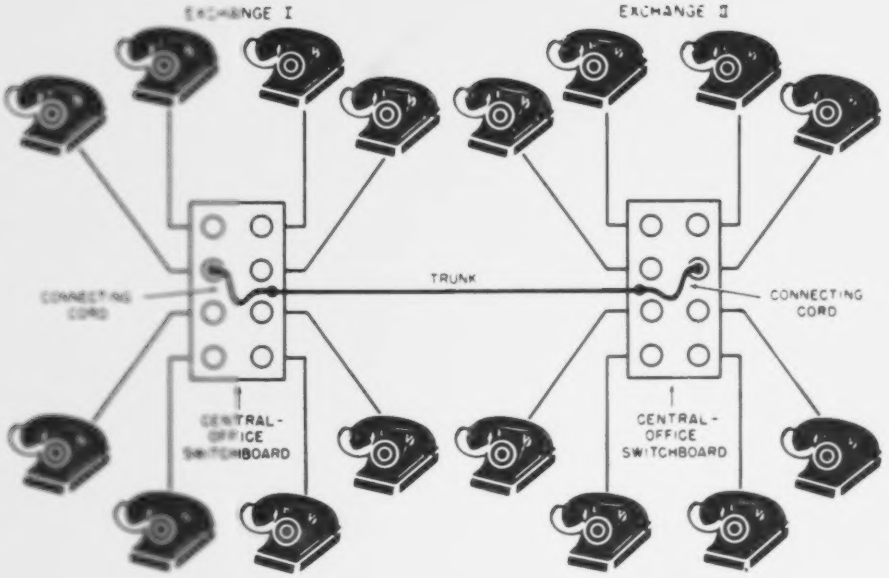

EXCHANGE I
EXCHANGE II
CONNECTING CORD
TRUNK
CONNECTING CORD
CENTRAL-OFFICE SWITCHBOARD
CENTRAL-OFFICE SWITCHBOARD

Figure 1-6. Telephone system.

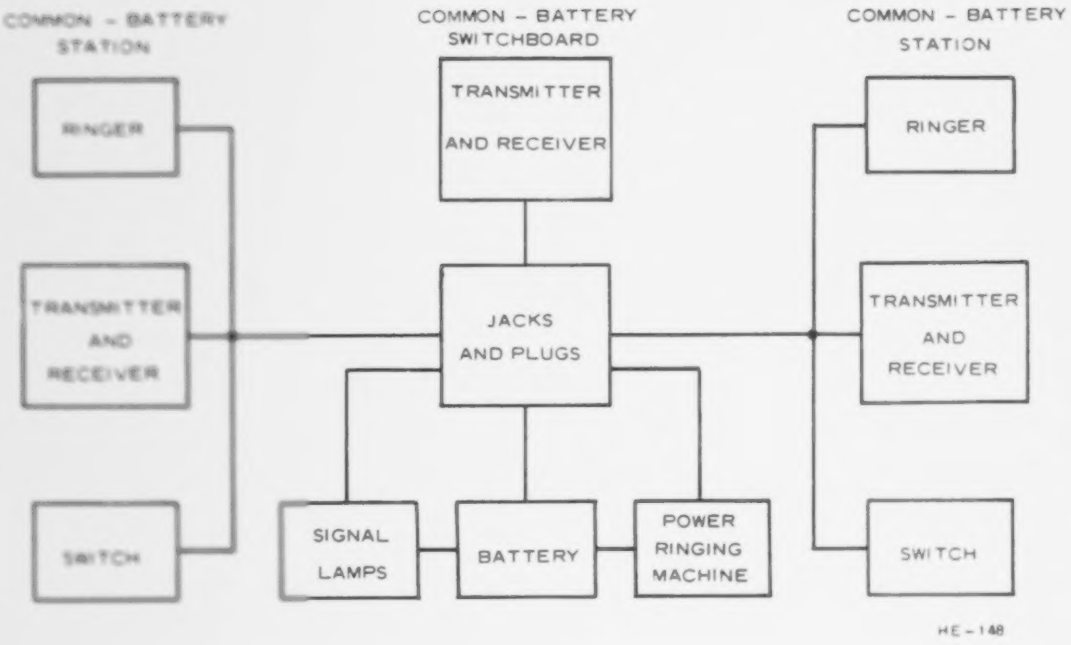

COMMON - BATTERY STATION
COMMON - BATTERY SWITCHBOARD
COMMON - BATTERY STATION
RINGER
TRANSMITTER AND RECEIVER
RINGER
TRANSMITTER AND RECEIVER
JACKS AND PLUGS
TRANSMITTER AND RECEIVER
SWITCH
SIGNAL LAMPS
BATTERY
POWER RINGING MACHINE
SWITCH
HE-148

Figure 1-7. Common-battery system block diagram.

In general, military field telephone systems are manually operated and may be either the local-battery or the common-battery type. The local-battery system is used more often than the common-battery system for temporary service. Where time is a factor and the system may later be improved (or removed), a local-battery system may be installed. Field wire lines can be used with it, since they can be installed and used under somewhat adverse conditions.

Common-Battery Advantages. The use of common-battery systems for permanent installations reduces battery costs and increases battery efficiency. Recharging batteries costs far less than buying new dry-cell batteries, and recharging is possible because the battery is at a central location. The storage battery of the common-battery system is more efficient than the dry-cell battery. (Also, the storage battery voltage is stable.)

In manual common-battery systems, the telephone user signals the switchboard simply by removing the receiver or handset from the hookswitch. Looking again at figure 1-3, note that the hookswitch is shown with two pairs of contacts—one pair located between terminals L2 and T and the other pair located between terminals GN and R. Both hookswitch contacts are closed, the position they assume when the handset is removed from its cradle. This completes the circuit for the direct current and lights the lamp on the switchboard. At the end of the call, the operator is again signaled by the lamp when the receiver is replaced on the hookswitch. Thus one operator can handle many more lines than would be possible otherwise. Note that the ringer with its capacitor is connected between terminals L1 and L2. Thus it is in position to receive ringing current via the telephone line. With this system no magneto at the subset is required, the subset equipment can be smaller, and the subscriber can use the subset with less difficulty.

Exercises (203):

1. What major equipment is at the central office?

2. What connects a telephone set to the central office equipment?

3. What do we call the lines that connect telephone exchanges together?

4. List telephone set components.

5. State two advantages of a central office battery over a local station battery.

6. What signaling advantage does a common battery system have over a local battery system?

7. What two local-battery telephone devices are deleted from a common-battery telephone?

CHAPTER 2

Station Equipment in Automatic Systems

TO INSTALL and maintain telephone equipment used by the Air Force, the telephone equipment installation and repair specialist must be familiar with both manual and automatic systems. Although most of the telephone systems used in the Air Force today are of the automatic (dial) type, you should understand both systems. You must be familiar with the transmitting, receiving, and signaling circuits, and you must understand telephone dials and dial circuits.

In this chapter we shall discuss the telephone equipment used with automatic telephone systems, first showing how central office equipment makes a telephone call possible. In doing this, we shall see how the common-battery systems operate. We have divided the chapter into the following sections: common-battery switching systems; the dial telephone circuits, including the touch-tone telephone; control of switching equipment; telephone dial construction, operation, and wiring; and the 500-type telephone and other types of telephones.

2-1. Common-Battery Switching Systems

Modern telephone systems are nearly all of the common-battery type. The electrical power is supplied from the central office. In *manual* common-battery systems, the switching and connecting is done by operators in the central office. In *dial* common-battery systems, the switching is done automatically in the central office and controlled by a dial on each telephone.

206. Name two electromechanical telephone switching systems and compare their operation.

The connections between telephones in a dial telephone system are made by switching mechanisms in the central office. These mechanisms are remotely controlled by the dial on the calling telephone and do not require the aid of an operator.

In addition to some relatively new electronic switching systems, there are two electromechanical types of dial telephone systems used by the Air Force: the Strowger system and the XY system. the two dial systems interconnect the telephones in basically the same way. The principal difference between the systems is in the equipment used.

Strowger System. This system has step-by-step switches that operate directly from dial pulses transmitted from the pulse-sending device (dial) on the telephone. Operation of the dial interrupts the line current by alternately opening and closing the dial pulse contacts. Each set of dial pulses (sometimes called train impulses or pulse trains) corresponds to the digit dialed by the telephone user. This pulse train extends a connection one step at a time (step-by-step) through the switching equipment to the called telephone. The wipers (or contacting arms of numerical, dial-controlled stepping switches) make the proper connections at the central office. Electromagnets operated by pulses from the dial on the calling telephone move the wipers one step at a time.

The operation of a step-by-step dial system is essentially the same as that of the manual system. For example, when the receiver is removed from the hookswitch in the manual system, the operator responds by connecting an answer cord to the calling line; that is, the operator finds the calling line with the answer cord. When the receiver is removed at a station in the dial system, a linefinder switch automatically finds the calling line and extends that line to a selector or connector switch, which connects a tone (dial tone) to the line. The dial tone has the same significance in the dial system as the operator's "number, please" in the manual system. Then the calling party, instead of giving the desired number verbally, dials each digit of the line number. When the number is dialed, the connector completes the connection and automatically applies ringing current to the called line. In the manual system, the operator connects the calling cord to the desired line and connects the ringing current. In both systems, however, battery current must be connected to the called line. This connection is made automatically in the dial system and in the manual system (when the operator releases the manually operated ringing switch).

In figures 2-1 and 2-2, you can see that each terminal bank of the switch has 10 rows of terminals with 10 terminals per row. These rows are numbered from the bottom to the top with the numbers 1 through 0, the 0 taking the place of 10. Also, the terminals in each row are numbered from left to right with the numbers 1 through 0. These row and terminal numbers combine to form a number for each terminal in the bank. For example, the telephone shown in the upper left corner of figure 2-1 is connected to terminal 91. The number 91 indicates that the phone is connected to the 1st terminal in the 9th row. As another example, the telephone shown in the lower right corner of figure 2-1 is connected to the 0 terminal in the 2d row; thus its number is 20. When a switch (such as the connector switch shown in figure 2-1) is dialed by the calling telephone, the wiper moves upward in response to the first digit dialed and then to the right in response to the second digit. Thus the dialing of 00 into the connector switch (figure 2-1) would place the wiper in the position shown.

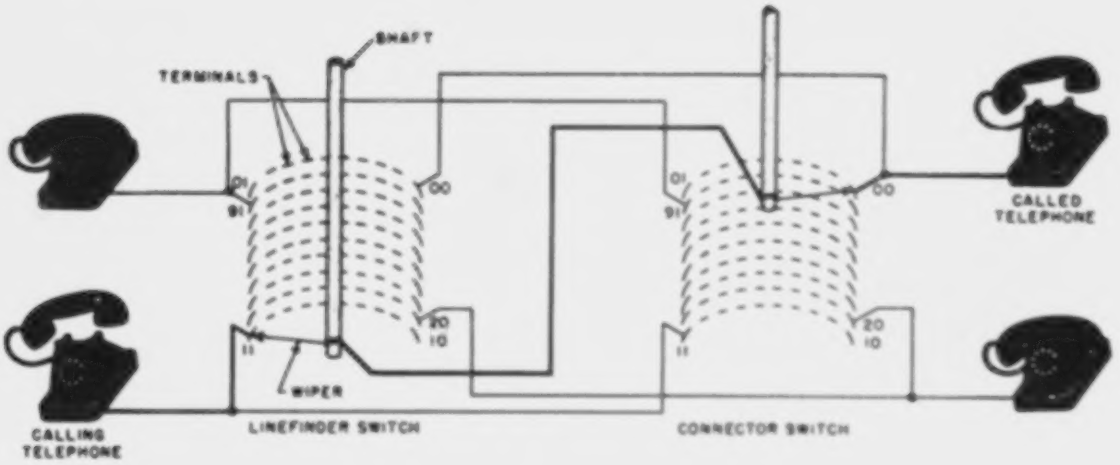


Figure 2-1. Simplified telephone dial switching action.

Although figure 2-1 shows only one bank for both switches, the actual switch (fig. 2-2) has two horizontal line banks and a vertical bank. Furthermore, it has three wipers for contacting the terminals of these switch banks. The wiper cords interconnect the wipers and bank terminals with the remaining circuit components.

XY System. The XY system is similar in operation to the step-by-step system. The main difference is in the type of stepping switches used. With the Strowger system, the switch operates in an upright position with the wipers stepping first vertically and then horizontally. With the XY system, the switch wipers step in two directions on the horizontal plane. First, the switch is stepped in the X direction (the direction designated as east on a map) and then in the Y direction (north on a map).

Figure 2-3 is an illustration of a partial XY switch. You can see numbers stamped on the guide rule and on the digit drum. This figure shows the X stepping mechanism as having first stepped twice, then the Y mechanism stepped four times. The switch position, in this case, is referred to as position 24.

Figure 2-4 shows that the XY switch has three banks and three sets of wipers; the X-XX, T and R, and the S and HS banks and wipers. The T and R and S and HS banks have ten levels with each level having two contacts per digit. Thus, by stepping in the X and then Y directions, the XY switch can make a chosen connection out of a group of 100 possible connections. *NOTE:* Each dot represents a wire contact that terminates a conductor. Since there are eleven dots to a row and 42 rows, there are 462 possible connecting points. You should see, too, that the wire contacts of the first row in each level of the T and R bank are the tip conductors and the second row wires complete the ring circuits.

Exercises (204):

1. How does the user activate the central office telephone equipment switches?
2. What two electromechanical telephone systems are used on Air Force bases?
3. Identify the telephone equipment switch that operates first following lifting of the handset from the hookswitch.
4. Identify the telephone equipment switch that connects ringing current to the called telephone.
5. Describe the operating principle by which a telephone dial selects a telephone for a user.
6. If the user at the lower right of figure 2-1 wants to originate a call, what switch does he activate?
7. For the telephone of question 1, how many steps up on the line bank does the line wiper take?
8. For the telephone of question 1, how many steps around the line bank does the line wiper take?
9. What two components on a Strowger connector switch make the final circuit connection for a call?

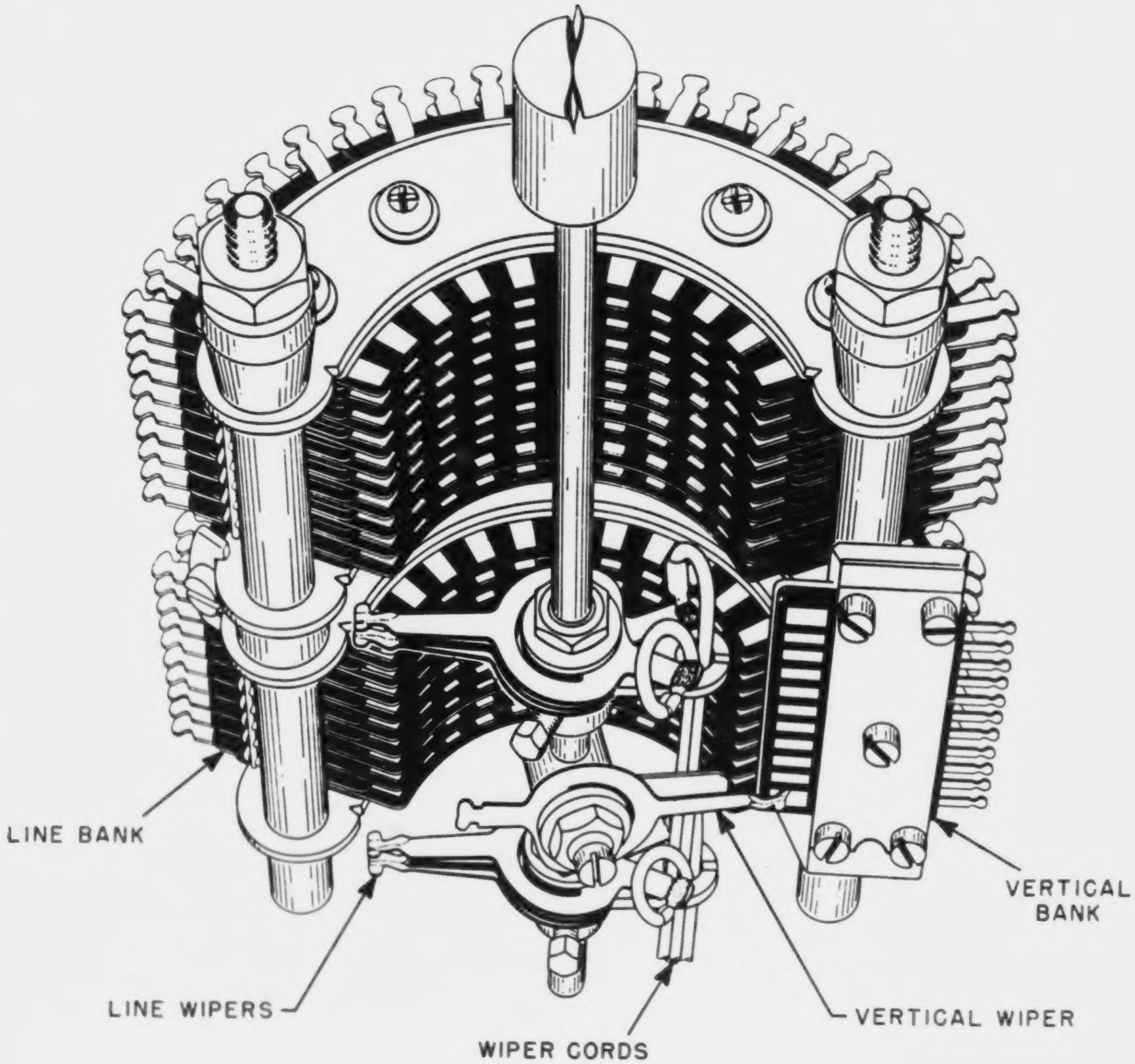


Figure 2–2. Telephone switch wipers and terminal banks.

10. How are the operations of XY and Strowger switches similar?

11. How do the operations of the XY and Strowger switches differ?

12. What two telephone switch components are the same for the XY and Strowger switches?

13. How does the XY switch complete a connection when a telephone set dial is operated?

2-2. The Dial Telephone Circuits

Without proper telephone connections and operation, of course, automatic systems will not function. The telephones that control the central office switching equipment are therefore very important.

205. State how a typical dial telephone works.

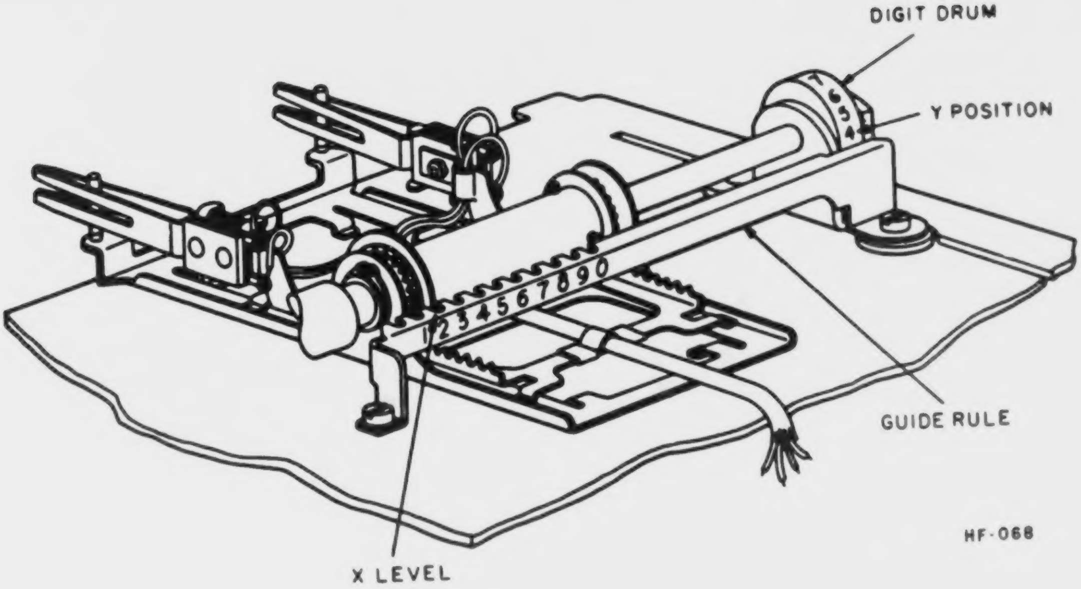
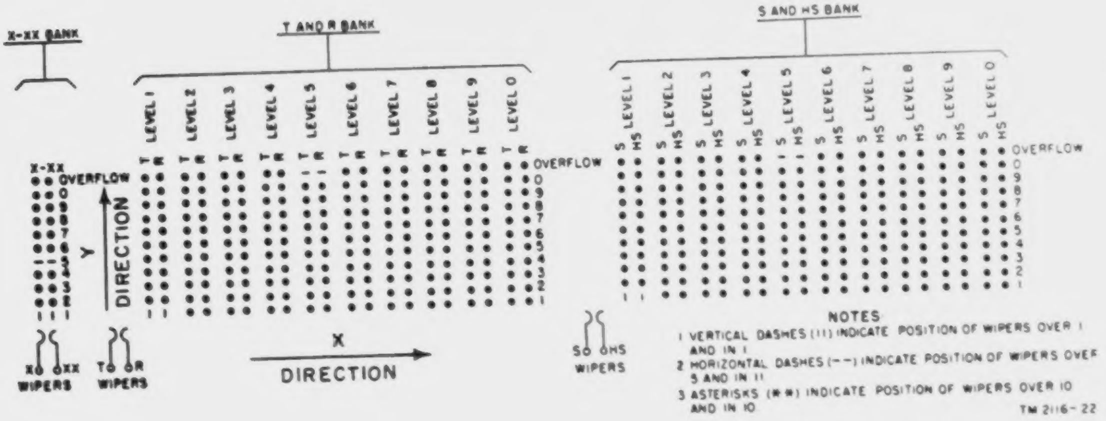

DIGIT DRUM
Y POSITION
1 2 3 4 5 6 7 8 9 0
GUIDE RULE
HF-068
X LEVEL

Figure 2-3. XY telephone switch stepped to position 24.


X-XX BANK
T AND R BANK
S AND HS BANK
X-XX
OVERFLOW
Y
DIRECTION
LEVEL 1
LEVEL 2
LEVEL 3
LEVEL 4
LEVEL 5
LEVEL 6
LEVEL 7
LEVEL 8
LEVEL 9
LEVEL 0
T
R
S
HS
OVERFLOW
0
9
8
7
6
5
4
3
2
1
XO OXX
WIPERS
TO OR
WIPERS
X
DIRECTION
SO OHS
WIPERS
TM 2116-22

NOTES
1 VERTICAL DASHES (II) INDICATE POSITION OF WIPERS OVER 1 AND IN 1
2 HORIZONTAL DASHES (--) INDICATE POSITION OF WIPERS OVER 5 AND IN 11
3 ASTERISKS (**) INDICATE POSITION OF WIPERS OVER 10 AND IN 10

Figure 2-4. XY switch bank, viewed from above.

Rotary Dials. The dial telephone set consists of parts necessary for the reception and transmission of speech, for signaling, and for controlling the central office switching equipment. Part A of figure 2-5 shows the circuits of a typical dial telephone used with dial central offices. Notice that the cradle hookswitch of the dial telephone set is in the talking position; that is, the handset is off the cradle switch, permitting the switch to close the loop of the calling telephone. The dial pulse springs are shown in their normal closed position. Their purpose is to open and close the calling line loop each time the dial returns to normal. When the pulse springs open, they interrupt the direct current flowing through the loop. Part B shows this loop (pulsing circuit). The resulting pulses, or interruptions in the current of the calling line loop, operate the switching equipment in the central office to extend connections from the calling telephone to the called telephone. The dial pulse springs open and close (break and make contact) as many times as the number dialed indicates, with the exception of the digit 0, which is an abbreviation for 10; that is, the dial pulse springs open and close 10 times in response to the dialing of digit 0. If the digit 5 is dialed, the pulse springs open and close 5 times in quick succession.

The shunt springs of the dial are shown in their initial open position because the dial in part A of figure 2-5 is not operated. When the dial is in the off-normal or rotated position (see part B of fig. 2-5), the shunt springs close and shunt out the receiver and transmitter so that they will not interfere with the pulses transmitted by the dial over the loop of the calling telephone. Shunting the receiver during dialing keeps the dial pulses from causing clicking sounds in the receiver. Shunting the transmitter improves the pulsing circuit by disconnecting the variable resistance of the transmitter during dialing. The shunts on the receiver and transmitter are removed when the springs return to their normal open positions each time the dial comes to rest in its normal position.

The ringing circuit in part C of figure 2-5 consists of the springs of the unoperated cradle switch, the ringer (bell), and the 0.7-microfarad capacitor. During ringing, the capacitor lets alternating (ringing) current flow through the telephone but blocks the flow of direct current. When the handset is lifted from the cradle switch, the capacitor and ringer are disconnected from a path directly across the loop of the telephone, and the capacitor is connected to the dial pulse springs to serve as a spark suppressor (to prevent excessive sparking or arcing at the contacts of the pulse springs). The 4-microfarad capacitor in the talking circuit (part D of fig. 2-5) improves the transmission efficiency of the telephone. The three-winding induction coil (wound on a laminated iron core) performs three functions:

a. Couples the receiver and transmitter to the loop of the telephone.

b. Increases the efficiency of transmission by boosting the voice frequency currents developed by the transmitter.

c. Minimizes sidetone. (Sidetone is the sound of one's own voice in the receiver of a telephone.)

The talking circuit consists of a transmitter, a receiver, an induction coil, a 4-microfarad capacitor, and the dial impulse springs. These circuit components are used for both transmission and reception.

Exercises (205):

1. What telephone set device opens and closes the cradle switch contacts?

2. What closes and opens the step-by-step switch operating circuit to advance the connection to the called party?

3. What device should you suspect if there is clicking in the receiver during dialing?

4. What user action connects the ringer to the line loop?

5. To which line terminal is the ringer circuit capacitor connected?

6. Which line terminal has a direct connection to an induction coil terminal?

206. State how a typical touch-tone telephone works.

Touch-tone Dial. You will often find the same function in telephone systems performed by two equipment units with different names. To illustrate, a dual-tone multifrequency (DTMF) key set does the same job as a touch-tone multifrequency (TTMF) subset. The key set may have more buttons and be used with a different system, but your depression of the pushbuttons produces the same results.

A touch-tone dial keyboard is illustrated in figure 2-6,A. Although this one has 12 pushbuttons, there are subscriber sets with 10 and 16 pushbuttons. The pushbuttons identified as P and C are used for special service signaling. For example, a conference connection between several stations could be made while using the C pushbutton. This type of subscriber set has an oscillator with several tapped terminals. (Another set may have a number of small solid-state oscillators.) Figure 2-6,B, identifies the *tone matrix*. Depression of each touch-tone pushbutton connects two tones to the telephone line. To illustrate, each pushbutton in figure 2-6,B, is represented by a circle and a digit. A depressed 7 pushbutton connects the tones 852 and 1209 to the line. Figure 2-6,B, shows the low frequency (852) at a horizontal line and the high frequency (1209) at a vertical line. With this arrangement, what frequencies are placed on the line when you press the touch-tone pushbutton 0? Yes, the low-frequency 941 and the high-frequency 1336 tones are connected to the line! The calling subscriber will hear

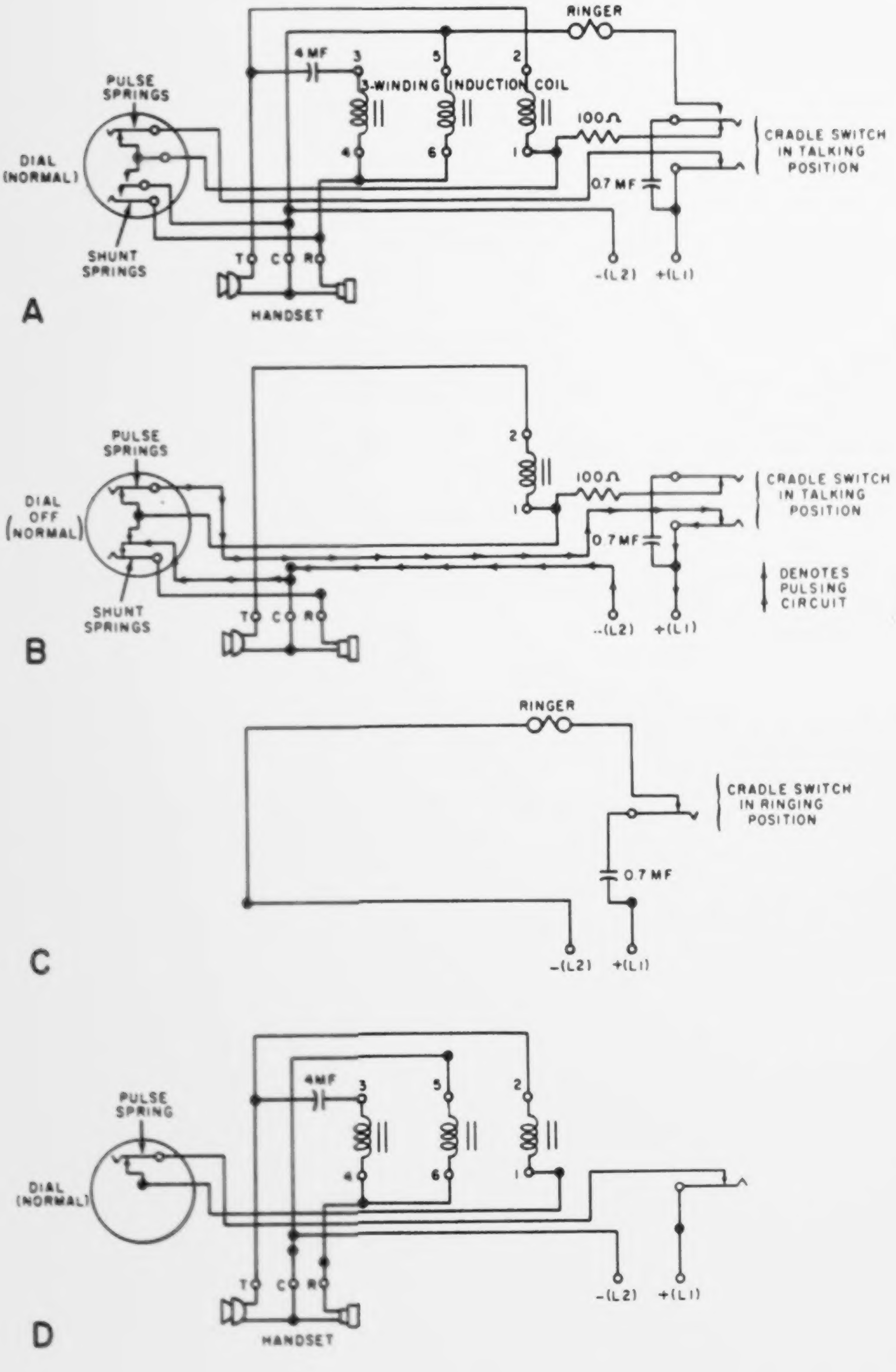

RINGER
4 MF
3
5
2
3-WINDING INDUCTION COIL
PULSE SPRINGS
DIAL (NORMAL)
100Ω
4
6
1
CRADLE SWITCH IN TALKING POSITION
0.7 MF
SHUNT SPRINGS
T
C
R
-(L2)
+(L1)
HANDSET
A
PULSE SPRINGS
DIAL OFF (NORMAL)
2
100Ω
1
CRADLE SWITCH IN TALKING POSITION
0.7 MF
DENOTES PULSING CIRCUIT
SHUNT SPRINGS
T
C
R
-(L2)
+(L1)
B
RINGER
CRADLE SWITCH IN RINGING POSITION
0.7 MF
-(L2)
+(L1)
C
4MF
3
5
2
PULSE SPRING
DIAL (NORMAL)
4
6
1
T
C
R
-(L2)
+(L1)
HANDSET
D

Figure 2-5. Typical dial telephone circuit.

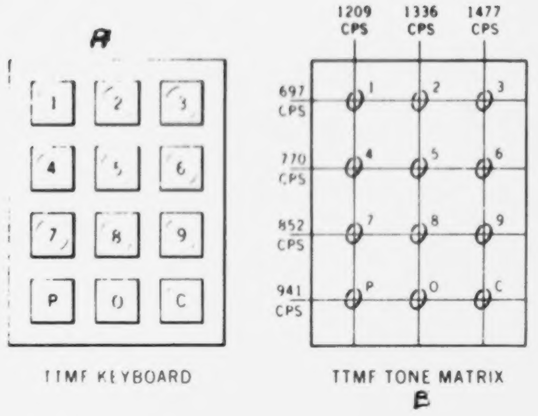


Figure 2-6. Touch-tone keyset key arrangement.

these tones. In time a caller can learn to recognize a good or bad selection simply by listening to the tones.

Telephone systems must be compatible. That is, each system must be able to operate with all other telephone systems. This includes specialized telephone equipment. Electronic equipment has been developed for use with electromechanical systems. This equipment must accept signals from two-way circuits and transform them to pulses that are usable in the regular telephone switching equipment. Similarly, signals from a rotary dial and a single pair must be usable in the switching center.

A lifted handset may do several things. You may see it operate a relay in the line equipment of the switching center. This is the normal response in a regular switching center. In the specialized equipment system, a receiver (electronic unit) is operated. As a result, dial tone is returned to the calling subscriber. This dial tone is provided by the selector of the telephone switching equipment or by the receiver of an associate electronic unit. Also the lifted handset may signal an operator at a switchboard. You can see, then, that the equipment that responds is determined by the system installed.

When you receive a dial tone and dial the selected number, the rotary dial pulses the dialing relays of the selector and the connector in a regular telephone system. The same relays can be affected when electronic equipment changes TTMF-originated tones to pulses. In this case, the tones operate a device in the electronic equipment, which, in turn, sends pulses to the incoming selector.

In another arrangement, the electronic equipment unit at the switching center accepts the two tones from a DTMF key set and either sends them in that form to a second electronic unit or transforms them to logic information for further use in the electronic equipment. *NOTE:* Logic information for our purposes refers to a second type of electronic signal. After the tones reach the electronic switching equipment and are transformed into pulses, they are sent to the succeeding electronic equipment. These pulses give the same result as does the duplicate digit from a rotary dial; they pick the line of the called party.

An incoming call to a PABX is processed by the operator. The call may be forwarded as tone signaling or pulse signaling. It may be completed by an electronic telephone system or an electromechanical system. Remember, if the calling station is a rotary-dial station on a two-wire line, the connection with the called two-wire station is completed with the familiar electromechanical methods. A connection to a touch-tone called station requires signal conversion for call completion.

The conversational circuit between a calling rotary dial station and a called touch-tone station requires conversion by the electronic switching equipment. Vice versa, the transmitting circuit between a calling touch-tone station and called rotary dial station also requires signal conversion. Units that provide signal conversion are referred to as "interface equipment."

All telephones permit a subscriber to actuate equipment in a switching center. Although the operation of the subset may be different, the end result is the same.

Exercises (206):

1. Identify two main units to a touch-tone keyset.

2. Refer to figure 2-6. What frequencies are provided when you depress pushbutton 3?

3. Describe the equipment actions required when a user depresses touch-tone pushbuttons to select a called party at a step-by-step system exchange.

4. How does telephone system "interface equipment" handle a call between an electromechanical system station and an electronic system station?

2-4. Control of Switching Equipment

Your have learned that a rotating dial interrupts the telephone line cirrcuit, thereby controlling the central office switching equipment. Figure 2-7 is a simplified schematic diagram of the subscriber's dial and its relationship to the central office equipment. Refer to this schematic as we discuss seizure, dialing, and release.

207. State what switch operations result from given subscriber actions at a telephone.

Seizure. When the subscriber removes the handset from the cradle of the telephone, the hookswitch operates and completes a path for current from ground through the upper winding of relay A, the hookswitch, the pulse springs, and

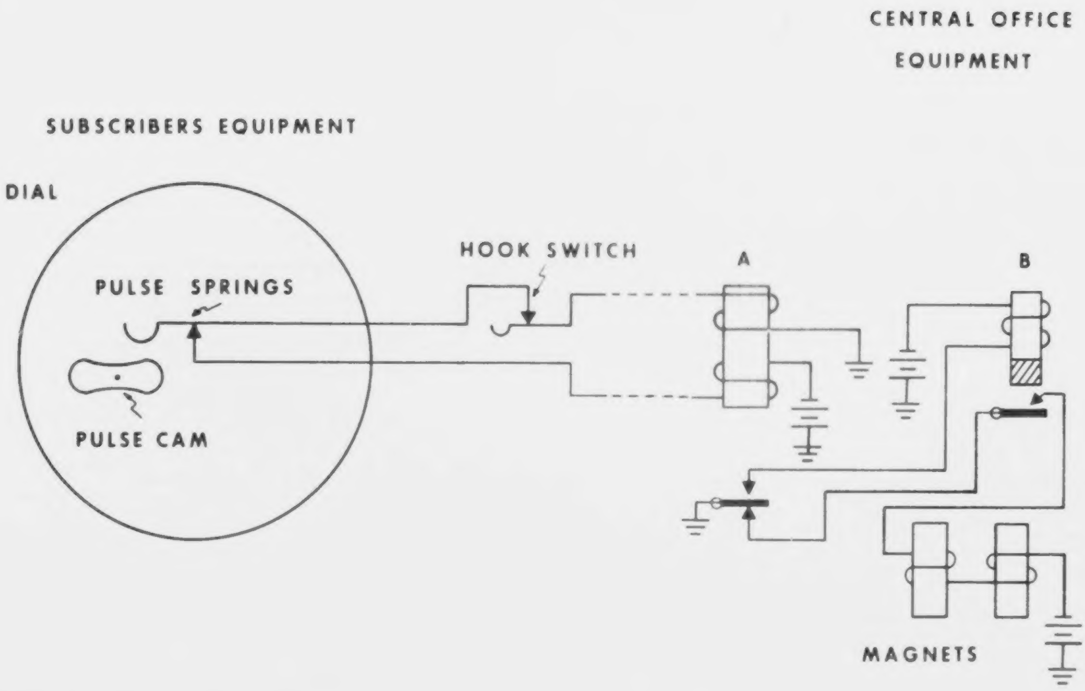


Figure 2-7. Simplified dial and switch circuit.

back through the lower winding of relay A to the battery and ground. Relay A operates to close its make contacts and complete a path for current through the winding of relay B and the make contacts of relay A to ground. Relay B operates to prepare an operating path for the magnets. The path to the magnets is open at the break contacts of relay A.

Dialing. The caller pulls the finger plate around to the finger stop. If the caller places a finger in the finger plate hole above the numeral 2, pulls the plate around to the finger stop, then releases it, there are 2 pulses, or interruptions, of current in the operating circuit of relay A. These pulses of current are listed below as break and make. Break and make state the condition of the dial pulse springs. The break condition exists when the pulse springs are open, permitting no current through relay A, which causes it to release. In the make condition the pulse springs are closed; this lets current through the relay A circuit and causes it to operate.

As the caller dials the number 2, the following sequence of events takes place:

a. 1st break
  (1) Relay A releases.
  (a) Opens the circuit to relay B. (Relay B does not release during pulsing as it is a slow-to-release relay.)
  (b) Closes the operating circuit to the magnets.
  (2) Magnets operate. (Magnet operation causes a step-by-step or XY switch to move its wipers one step.)
b. 1st make
  (1) Relay A reoperates.
  (a) Opens the circuit to the magnets.
  (b) Closes the circuit to relay B.
  (2) Magnets release.
c. 2d break
  (1) Relay A releases.
  (a) Opens the circuit to relay B.
  (b) Closes the circuit again to the magnets.
  (2) Magnets reoperate. (Steps the switch one more step.)
d. 2d make
  (1) Relay A reoperates.
  (a) Opens the circuit to the magnets.
  (b) Closes the circuit to relay B.
  (2) Magnets release.

When the subscriber dials a larger number, there are more breaks and makes, operating and releasing the magnets more times. For example, if the digit dialed is 6, there are 6 breaks and makes, operating and releasing the magnets 6 times, which, in turn, step the switch 6 times.

Release. When a caller hangs up (places the handset on the cradle switch), the circuit of relay A is opened. Relay A releases and opens the circuit to relay B, which, after a delay, also releases.

Exercises (207):

1. What central office equipment component operates when the dial telephone handset is first lifted from the cradle?

2. Identify the operated Strowger switch components that follow the dial pulses.

3. What results should be noted at the central office following replacement of the handset on the telephone cradle?

2-4. Telephone Dial Construction, Operation, and Wiring

The telephone dial shown in figure 2-8 is the unit the subscriber uses to control the central office switching equipment. It is a pulse-sending device, or circuit interrupter, operated by the calling subscriber.

213. Name the parts of a dial, and state what they do.

Parts of the Dial. Although the dial shown in figure 2-8 is not of the most recent design, it illustrates the basic parts of a typical telephone dial. As shown in the illustration, the dial consists of the following basic parts: number plate, finger plate, finger stop, mounting plate, pulse cam, pulse spring assembly, shunt spring assembly, shunt cam assembly, and governor assembly. Two additional parts for the dial are not identified--the helical restoring spring and the ratchet driv and governor assembly. Two additional parts for the dial are not identified—the helical restoring spring and the ratchet drive mechanism.

Number plate. The number plate contains the numerals 1 through 0. On the metropolitan dial, the letters of the alphabet are included.

Finger plate. The finger plate contains 10 holes equally spaced. When the dial is at normal, each hole is located over one of the numerals on the number plate. The dial card attached to the finger plate usually has the subscriber's telephone number.

Finger stop. The finger stop is a metal projection that extends over the surface of the finger plate to stop the finger at the same position every time.

Mounting plate. The mounting plate is a shallow metal cup to which all of the dial parts are attached. It is a means for mounting the dial to the telephone.

Pulse cam. The pulse cam is a two-lobed cam that actuates the main pulse spring. The cam is driven by the main drive gear as the finger plate returns to normal.

Pulse spring assembly. The pulse spring assembly consists of two contact springs and a back stop. The pulse springs are actuated by the pulse cam.

Shunt spring assembly. The shunt springs (sometimes called off-normal contacts) are on the dial to shunt out the receiver and transmitter during the pulsing period. The shunt springs are held open by the shunt cam when the finger plate is at normal. As soon as the finger plate is moved off normal, the shunt cam closes the contacts until the finger plate again returns to normal.

Shunt cam. The shunt cam is a two-lobed brass cam mounted on the end of the main dial shaft. One lobe of the cam actuates the shunt springs; the other lobe moves the pulse springs away from the pulse cam after the last pulse to give a time delay between the last pulse of one digit and the first pulse of the next digit.

Governor assembly. The dial governor automatically regulates the speed of the dial pulses to insure uniform response of the central office switching equipment. The pulsing speed of a properly adjusted dial is 10 pulses per second. The dial timing must be highly accurate to allow the switching equipment to function. Proper governor setting insures that the pulses are sent at the correct speed. The acceptable speed for the dial most used in today's telephone is 9 to 11 pulses per second (pps); 10 pps would be perfect. When you suspect dial trouble on a bench repair or trouble report, call the test board for a dial check. The central office has the test equipment to check the speed of the dial.

Helical restoring spring. The helical restoring spring attached to the main drive gear shaft furnishes the power to operate the dial during the pulsing period.

Ratchet drive mechanism. The ratchet drive mechanism consists of a pawl and ratchet gear attached to the main drive gear. As the finger plate is operated, the pawl clicks over the ratchet teeth so that the pulse cam and governor remain at rest. As soon as the finger plate is released and begins to restore, the pawl engages one of the ratchet teeth and sets the dial mechanism into motion. On later model dials using the friction type pawl silencer, the pawl is lifted away from the ratchet teeth as the dial is moved off normal and does not drop into engagement with the ratchet teeth until the finger plate is released.

Dial Operation. In general, the operations of all dials are similar. To dial a number, the caller places a finger in the finger plate hole over the digit and then turns the plate clockwise until the finger hits the finger stop. This turning winds the dial drive spring and operates the dial shunt contacts. The dial is then ready to function. When the caller releases the finger plate, the drive spring returns the mechanism to the unoperated position. While the mechanism is returning to this position, the pulse cam operates the pulsing springs, opening and closing the pulsing circuit the same number of times as the number of the digit dialed. As the finger plate reaches its unoperated position, the shunt contacts return to their normal position. A governor controls the return speed, thus determining the rapidity of the pulsing operation.

Although many telephone dials are constructed differently, the pulsing springs on all dials work approximately the same. The main difference between the various types of dials is in the operation of the shunting spring contacts. To observe this difference in shunting spring operation, refer to the schematic diagram in figure 2-9. The heavy lines in this illustration indicate the path of the dial pulses. Note that when the dial contacts between springs 3 and 4 are operated, they short-circuit not only the transmitter but also the primary winding of the induction coil. Short-circuiting the primary winding reduces interference between the telephone and any nearby radio equipment during the dialing period; it also reduces the dialing circuit resistance. Also note that the dial contacts between springs 5

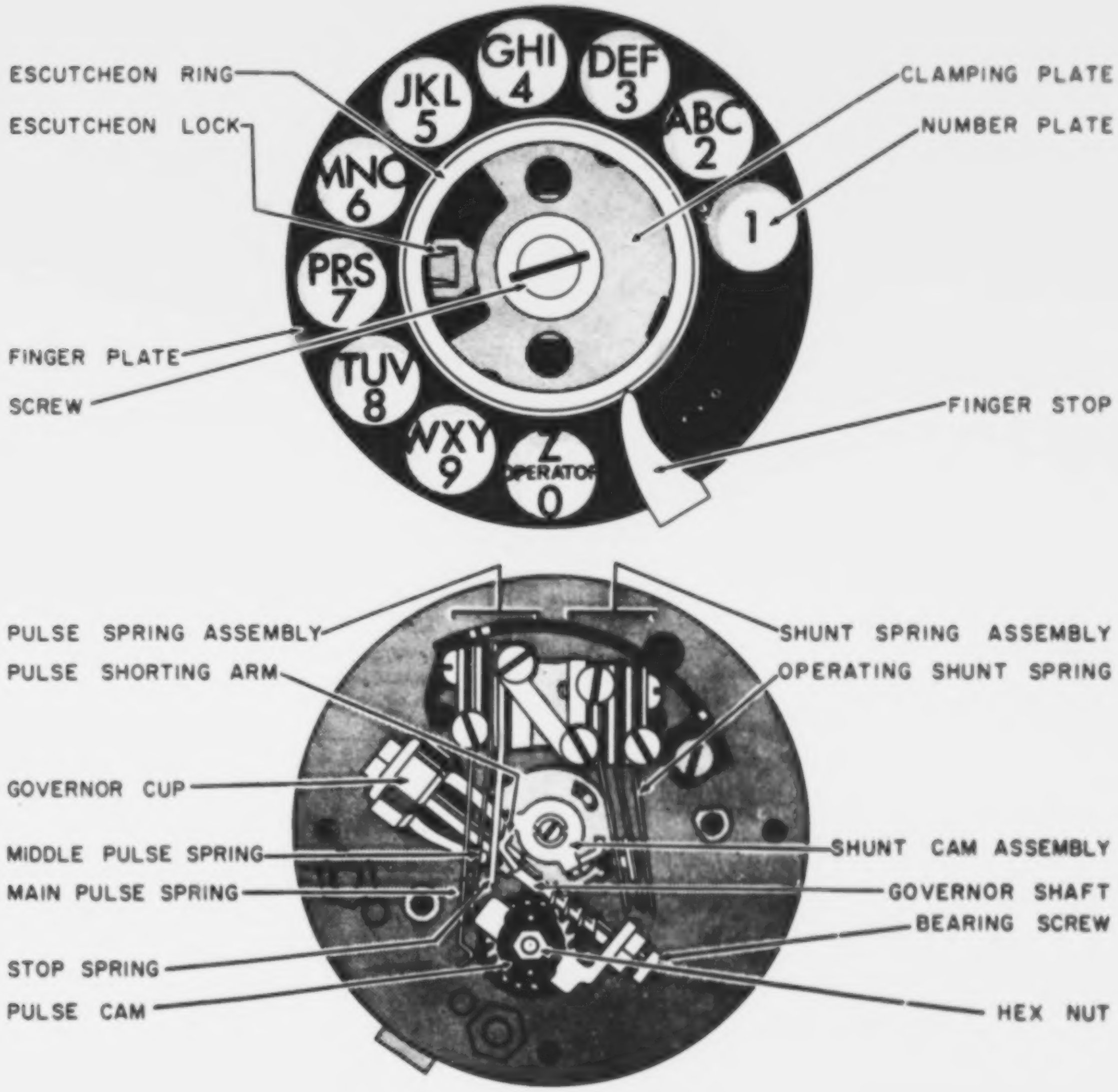

ESCUTCHEON RING
ESCUTCHEON LOCK
FINGER PLATE
SCREW
CLAMPING PLATE
NUMBER PLATE
FINGER STOP
GHI 4
DEF 3
ABC 2
1
JKL 5
MNO 6
PRS 7
TUV 8
WXY 9
Z OPERATOR 0
PULSE SPRING ASSEMBLY
PULSE SHORTING ARM
GOVERNOR CUP
MIDDLE PULSE SPRING
MAIN PULSE SPRING
STOP SPRING
PULSE CAM
SHUNT SPRING ASSEMBLY
OPERATING SHUNT SPRING
SHUNT CAM ASSEMBLY
GOVERNOR SHAFT
BEARING SCREW
HEX NUT

Figure 2-8. Typical telephone dial.

and 6 (fig. 2-9) open the receiver circuit when the dial is moved off normal. This is directly opposite from the circuitry shown in figure 2-5, where the receiver circuit is shorted by the shunt springs. In figure 2-9, the pulsing contacts (1 and 2) are always closed except while the dial finger plate is returning to normal. When a digit is dialed on this telephone, the pulse cam opens and closes these contacts while the finger plate is returning to normal. The number of times the contacts open and close corresponds to the number of the digit dialed. Thus these contacts pulse the line circuit, causing current surges that control the switching equipment at the central office.

Exercises (208):

1. In looking at the face of a telephone dial, what are its three very evident parts?

2. What two cams break and make the contacts in the pulse and shunt spring assemblies?

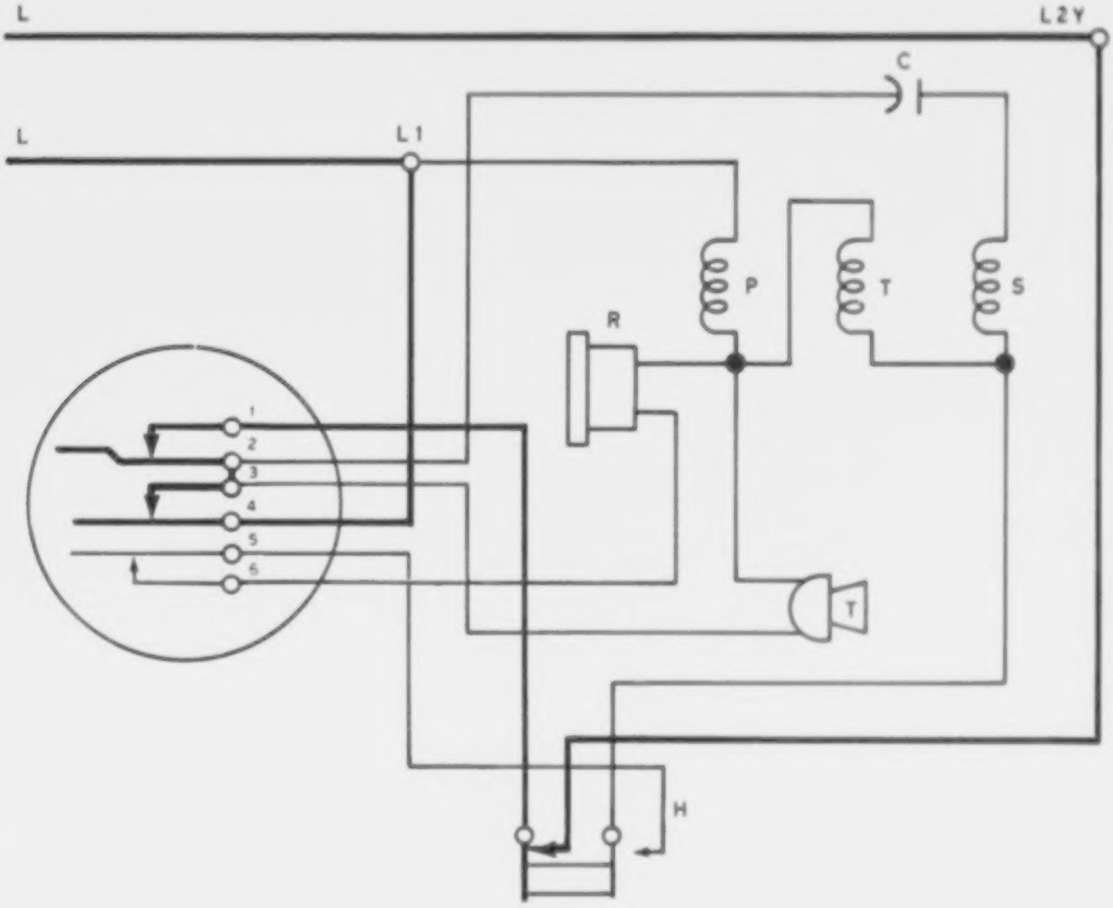


Figure 2-9. Dialing circuit schematic diagram.

3. What dial spring contacts open the telephone lines after operation of the dial?

4. What do the shunt springs do?

5. What dial device prevents the selection of wrong numbers when a number is dialed?

6. Identify the cam that physically opens and closes the telephone line circuit by moving dial springs following release of the finger plate.

7. Identify the dialing circuit components in text figure 2-9 that are in parallel with spring terminals 3 and 4.

8. How may dial spring assemblies vary from set to set?

2-5. The 500-Type Telephone

The subset that is most widely used in the Air Force is the commercial 500 telephone. Although the 500-type telephone is manufactured by most of the major telephone equipment manufacturers, the only two with interchangeable parts and circuits are those manufactured by Western Electric Company and by ITT-Kellogg. When we speak of the 500 telephone, we are referring to the identical instruments made by these two companies. The 500 telephone illustrated in figure 2-10 is of the type that is commonly used now. As you can see in the illustration, the part identified as the finger plate in figure 2-8 is called the dial wheel. Note also that the dial numbers and letters are located on a plate outside the dial wheel rather than under it. Let's first discuss the set's components and construction and then its circuits and operation.

209. Associate telephone components with their functions, and identify probable maintenance actions.

The major components of the 500 telephone are a handset, a telephone housing assembly, a handset cord, and a mounting or deskstand cord. The handset is shorter than the older types, thus placing the transmitter closer to the speaker's mouth during operation. The handset cord uses four conductors, two for the transmitter and two for the receiver. Remember that the older handset cord uses three conductors; one for the receiver, one for the transmitter, and one that is common to both the transmitter and receiver.

For a telephone to operate in an automatic system, it must have the seven basic parts: a transmitter, a receiver, a hookswitch, a ringer, a dial, an induction coil, and a capacitor. All of these parts are necessary if the telephone is to operate satisfactorily. The 500 telephone uses all of them, plus some additional ones to improve its operation.

Transmitter. Although the 500 telephone transmitter looks like the older type of carbon transmitter, its operation has been greatly improved. One of the main improvements is a special treatment of the carbon granules, which provides continuously a more uniform contact and thus improves the quality of transmission. Also, the transmitter simply rests in a plastic cup mounted in the handset opening just below the transmitter unit (see fig. 1-1). The transmitter conductors from the handset cord are connected to the lower side of the plastic cup by screw-type terminals. These terminals extend through the plastic cup to spring contacts, which, in turn, engage silver contacts on the lower side of the transmitter unit. Thus you can unscrew the cap that holds the transmitter unit in place, lift the transmitter unit off the spring contacts and insert a new one. Besides being a mounting for the transmitter unit, the plastic cup performs other important functions in the handset. First, because of its shape, it forms a controlled acoustic cavity back of the transmitting unit. Second, the cup provides an acoustic shield between the transmitter and receiver. If it were not for this acoustic shield, the sound would travel through the hollow handle of the handset from the transmitter to the receiver and vice versa, with an adverse affect on both transmission and reception.

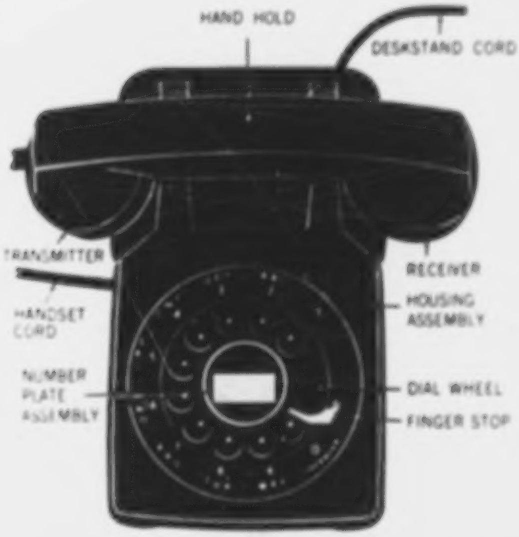


Figure 2-10. 500-type telephone.

Receiver. The receiver is shown in figure 1-2. Note that this receiver has a ring magnet that greatly improves its operation. Also, its dome-shaped diaphragm makes it much more efficient and gives it a greater frequency response than the older receivers. Because this receiver is so efficient, a varistor is connected across the terminals to protect the user from high acoustic levels that might be caused by stray electrical voltages entering the telephone circuit. The varistor also protects the receiver magnet from being demagnetized by such stray voltages. Unlike the transmitter conductors, the receiver conductors from the handset cord are connected to the receiver unit by terminal screws. Thus you must disconnect these terminals before you can remove the receiver unit.

Hookswitch. Rivets attach the hookswitch mounting bracket to the telephone base plate. The switch assembly with its protective plastic housing is attached to the mounting bracket so that the switch control lever can operate its contacts. Figure 2-11 shows the contacts in two positions. In part A, they are in the position they assume when the handset is in place on its cradle; in part B, they are in the position they assume when you life the handset.

In part B, the contacts are identified alphabetically by the letters A through G. As you will see later, these letters are used in schematic drawings to identify the hookswitch contacts. In part A of the illustration, contacts F and G are closed to short out the receiver when the handset is in place on its cradle. Also the line to network contacts (B to C and D to E) are open when the handset is in place. Therefore, except for the ringer, the telephone components are disconnected from the line whenever the handset is on its cradle.

In part B of figure 2-11, the shorting contacts (F and G) are open, thus removing the short from the receiver circuit. Also, the line to network contacts (B to C and D to E) is closed to connect the line to the network and telephone circuitry. The ringer-to-line contacts (A to B) are open. Note, however, that the ringer lead to contact A is not normally used in the ringer circuit. It is used only for special types of service.

Ringer. The ringer components (fig. 2-12) include a ringer frame, two ringer coils wound on one spool, a coil core, two permanently mounted resonator shells, two brass

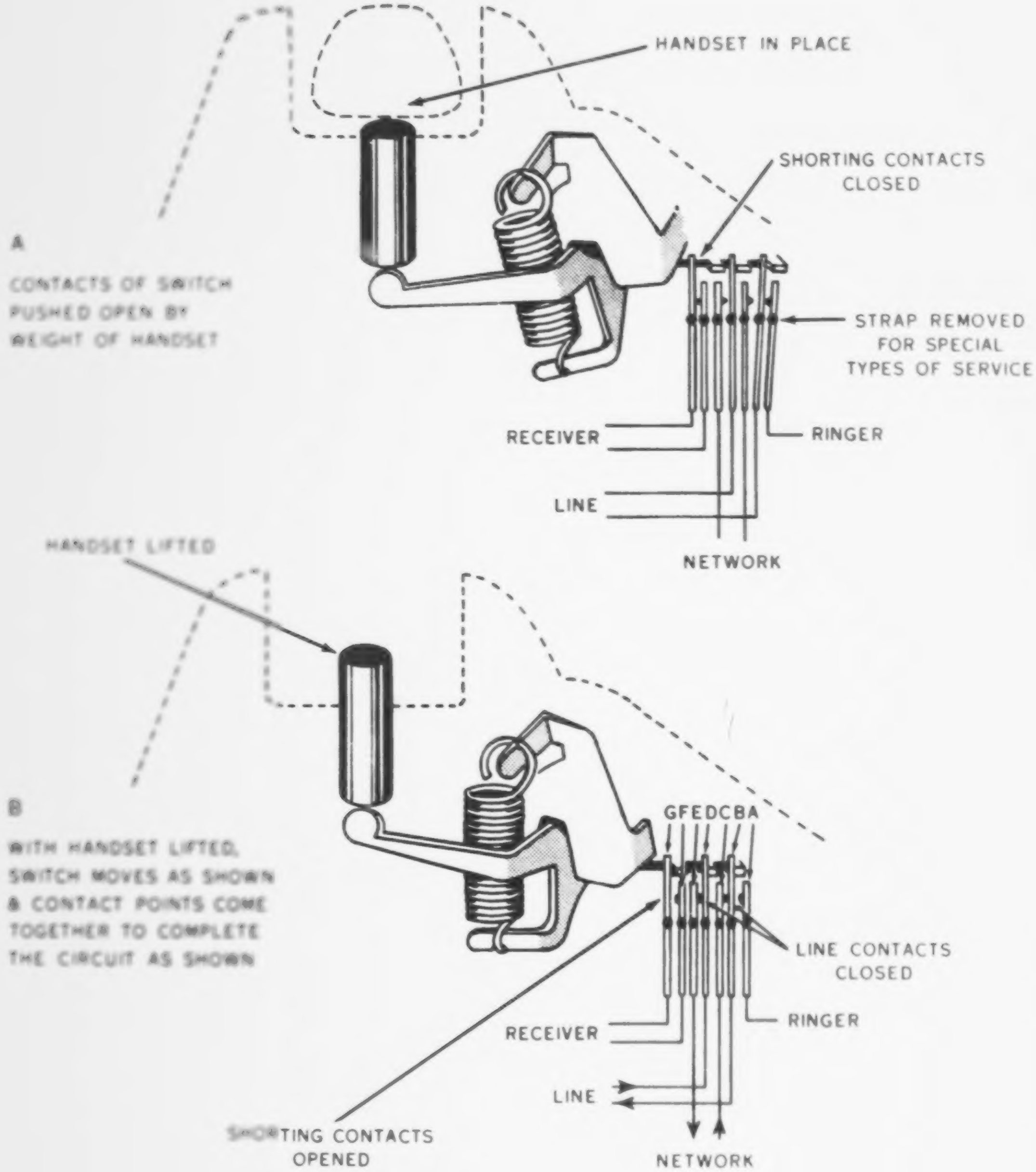

HANDSET IN PLACE
SHORTING CONTACTS CLOSED
A
CONTACTS OF SWITCH PUSHED OPEN BY WEIGHT OF HANDSET
STRAP REMOVED FOR SPECIAL TYPES OF SERVICE
RECEIVER
RINGER
LINE
NETWORK
HANDSET LIFTED
B
WITH HANDSET LIFTED, SWITCH MOVES AS SHOWN & CONTACT POINTS COME TOGETHER TO COMPLETE THE CIRCUIT AS SHOWN
GFEDCBA
LINE CONTACTS CLOSED
RECEIVER
RINGER
LINE
SHORTING CONTACTS OPENED
NETWORK

Figure 2–11. 500-type telephone cradleswitch (cut-away).

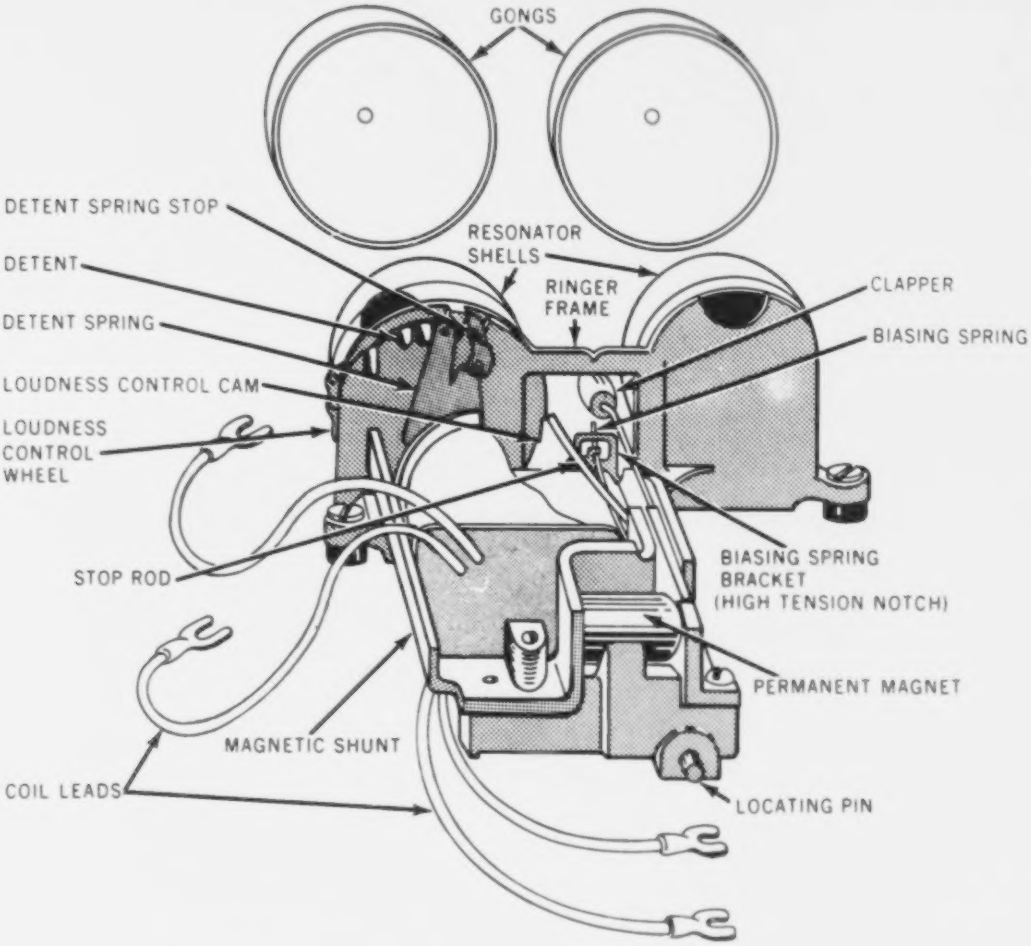

GONGS
DETENT SPRING STOP
RESONATOR SHELLS
DETENT
RINGER FRAME
CLAPPER
DETENT SPRING
BIASING SPRING
LOUDNESS CONTROL CAM
LOUDNESS CONTROL WHEEL
STOP ROD
BIASING SPRING BRACKET (HIGH TENSION NOTCH)
PERMANENT MAGNET
MAGNETIC SHUNT
COIL LEADS
LOCATING PIN

Figure 2-12. 500-type telephone ringer.

gongs, a biasing spring, an armature stop rod, and a ringer loudness-control arrangement.

The ringer parts are attached to the ringer frame and the entire assembly is mounted on the telephone base plate. The loudness-control is made accessible to the user by a knurled section on a control wheel that extends through a rectangular slot in the base plate. The entire ringer can be replaced as an assembly; or the ringer coil, coil core, and brass gongs can be replaced individually. Other than these, the ringer parts are not replaceable at any maintenance level. As you can see in figure 2-12, the biasing spring tension is determined by placing the spring in one of two notches on the biasing spring bracket. One notch provides high tensions, and the other notch, low tension. If it becomes necessary to remove and replace the ringer coil, you must use care to maintain polarity of the coil core and permanent magnet. If the permanent magnet becomes discharged, it must be remagnetized before the ringer can be used. One reason for this is that the ringer operates with two coils wound on one core to form one electromagnet. The permanent magnet must furnish magnetic force normally furnished by a second electromagnet on other ringers.

Dial. Figure 2-13 shows a rear view of the dial assembly. In this illustration, the protective housing has been removed to provide a better view of the parts. As you can see in the illustration, this dial has basically the same parts as those discussed previously but they are constructed and arranged differently. The dial contact springs, molded in a block of insulating material, have attached leads that are equipped with spade tips to facilitate their connection. When the telephone is assembled, these dial leads are connected to screw terminals on the network terminal board. There are only two pairs of contact springs on this dial: one pair for pulsing, and the other pair for short-circuiting the receiver winding when the dial is in the off-normal position. While these springs are called "shunt contacts" in figure 2-13, they are called the "off-normal contacts" in many diagrams and drawings.

When the dial is completely assembled, the mechanism is protected by a plastic housing that covers all the parts except

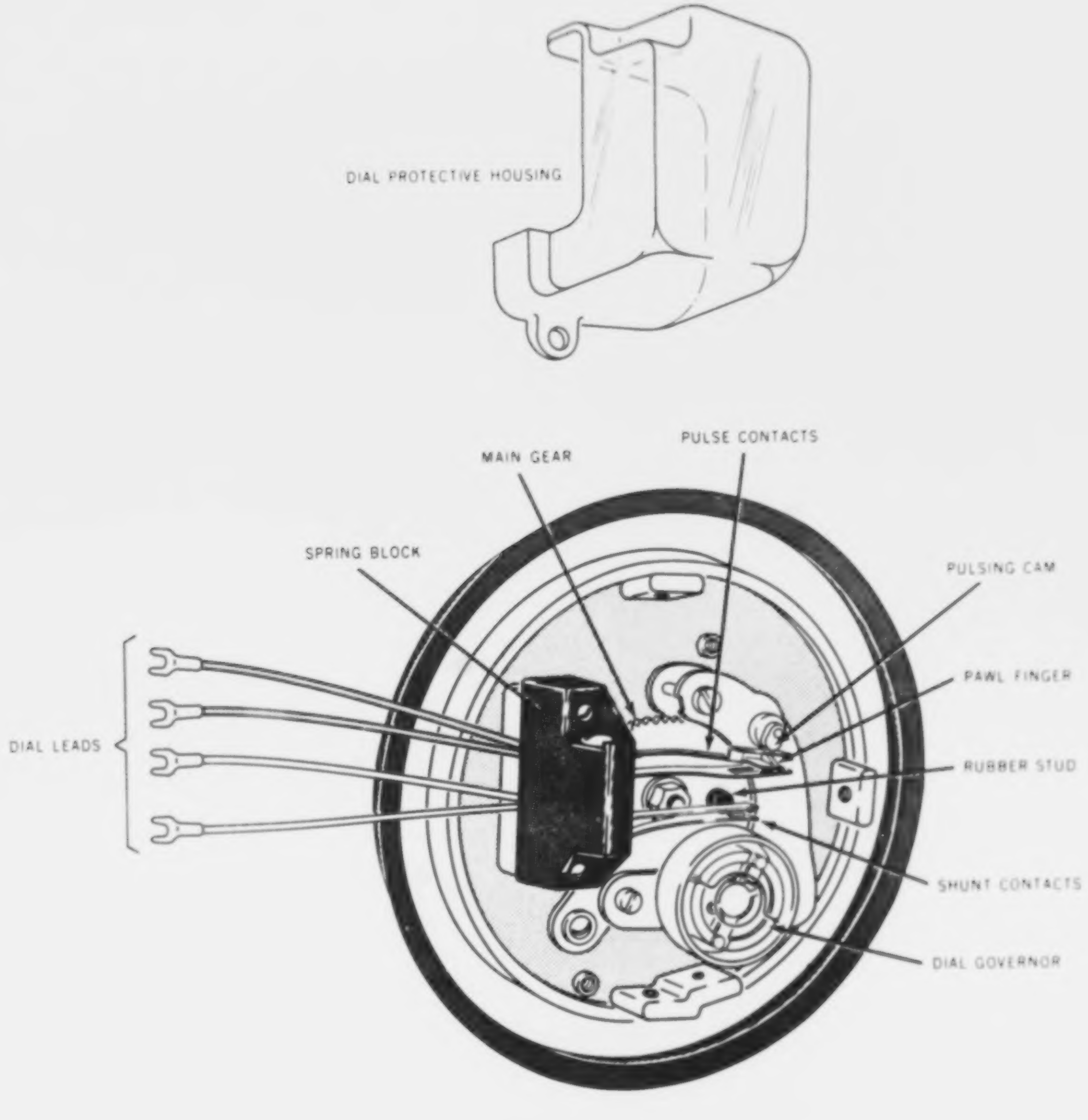


Figure 2–13. 500-type telephone dial (rear view).

the spring terminals leads. When the telephone is assembled, the dial assembly is mounted on a dial mounting bracket riveted to the telephone base plate.

Network. In the previous paragraphs we discussed the transmitter, receiver, hookswitch, ringer, and dial. These are only five of the seven components necessary for the operation of a modern telephone. The induction coil and the capacitor are sealed into the network assembly (fig. 1-4) in the telephone.

The network assembly parts are mounted in a metal container with their leads brought out to terminals on a plastic terminal board. In addition to the induction coil and ringing capacitor, there are three other capacitors, three resistors, and two varistors in the network assembly. The parts are assembled and placed in the can, and then the remaining air space in the can is filled with a moisture-proof sealing compound. This procedure seals the network so effectively that very little trouble is experienced with this part of the telephone.

As the telephone is assembled, the network is riveted to the telephone base plate. When a part of the network goes bad, it is the usual practice to replace either the network or the telephone. Normally the telephone is replaced for the customer and the old telephone is taken to the shop, to replace the network assembly. In some cases when the ringing capacitor goes bad, it may be corrected by installing a special capacitor on the outside of the network. To give you a better understanding of the network, we shall discuss its internal circuits along with the circuits used in the 500 telephone. But before we discuss these circuits, let's briefly consider the arrangement of the telephone components and parts.

Figure 2-14 is an illustration of the telephone assembly with the housing removed. Note the location of the various parts. The dial is mounted on a bracket at the right of the illustration. The hookswitch, with its arms extended out over the other components, is mounted next to the dial. The ringer and network assemblies are also plainly visible. You can see where the handset and mounting cords are held by metal fastening devices at the edge of the telephone base plate.

Exercises (209):

1. Refer to figure 2-14, to what telephone parts do the conductors of the "Cord to Handset" attach?
2. How does the handset cord connect to the transmitter?
3. Give two functions for the transmitter plastic cup.
4. What receiver unit reduces the effects of stray electrical voltages?
5. How do you connect the handset cord to the 500 telephone receiver?
6. On figure 2-11, what hookswitch contacts connect the telephone set mounting cord conductors with the network induction coil?
7. What is the position of the contacts of question 6 when the handset is lifted from the cradle?
8. What parts are replaceable on the 500 telephone ringer?
9. What is the probable maintenance action for a 500 telephone ringer that has lost its polarity?
10. Describe the method used to connect the dial assembly to the network terminals.
11. What is the usual maintenance procedure for defective networks?

210. Identify the five 500 telephone circuits and the component symbols on a circuit diagram.

The circuitry of the 500 telephone includes the ringer, transmitter, receiver, dial, and antisidetone circuits. These five circuits are all included in the wiring diagram illustrated in figure 2-15, which is actually a complete schematic wiring diagram for the 500 telephone. Before we discuss the five circuits, let's mention some general points about the wiring diagram. First, the network parts and terminals are all shown inside a dotted line on the diagram. The terminals, with their identifying letters and numerals, are shown in the same relative positions as they appear on the network itelf. The internal parts of the network have been identified with letters and numerals in the illustration. For example, the primary windings of the induction coil are identified as P1 and P2; the secondary windings are S1 and S2. The resistors are identified as R1, R2, and R3; the capacitors as C1, C2, C3, and C4; and the varistors as CR1 and CR2. We point this out because many diagrams don't identify the network parts, since they are not replaceable as individual parts. When it is necessary to identify the network parts, the identifying symbols shown in figure 2-15 are normally used.

Now observe the conductors at the upper right of figure 2-15 identified as T and R. The T and R stand for tip and ring. Tip and ring, as you may recall from the resident course, refer to the lines from the central office, the names coming from the parts of the jack and plug used on the manual common-battery switchboard. The ring side of the line is always connected to negative battery at the central office, and the tip side is connected to positive battery and ground. Thus, in respect to the battery current, the ring side of the line is negative and the tip side of the line is positive. The tip side of the line is connected to ground at the central office except during the ringing period in certain types of ringing systems. (This feature will be further explained along with ringing systems in a later volume.)

A ground symbol on a telephone schematic usually means a common connection to positive battery. If an earth ground is intended, it is usually so marked on the diagram. This applies to the ground used during telephone installation, such as the connection to a water pipe, a ground rod, etc.

To make it easier to locate the two sides of the line at connecting blocks and terminals, it is customary to connect the ring side of the line on the right-hand terminal and the tip

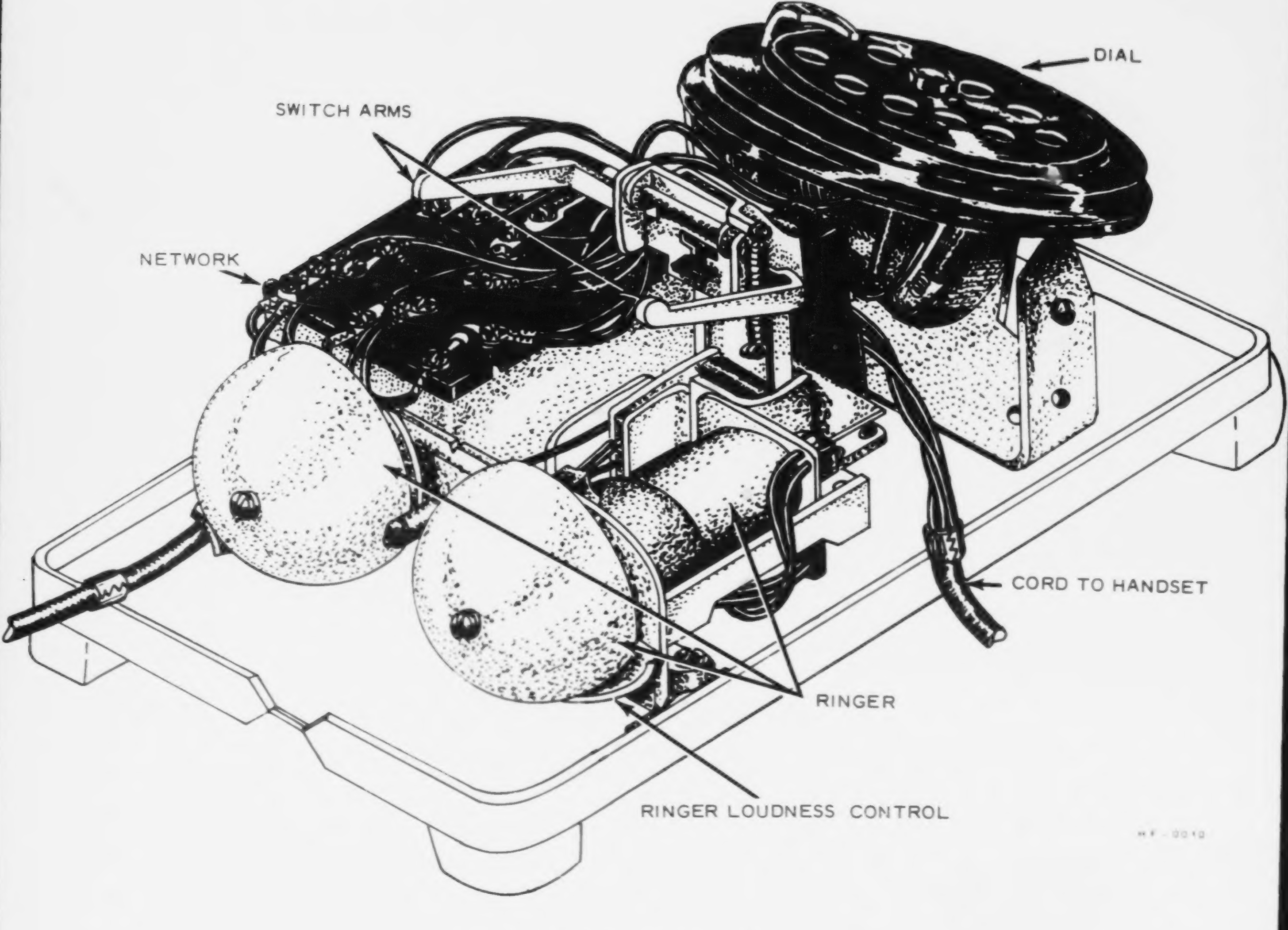
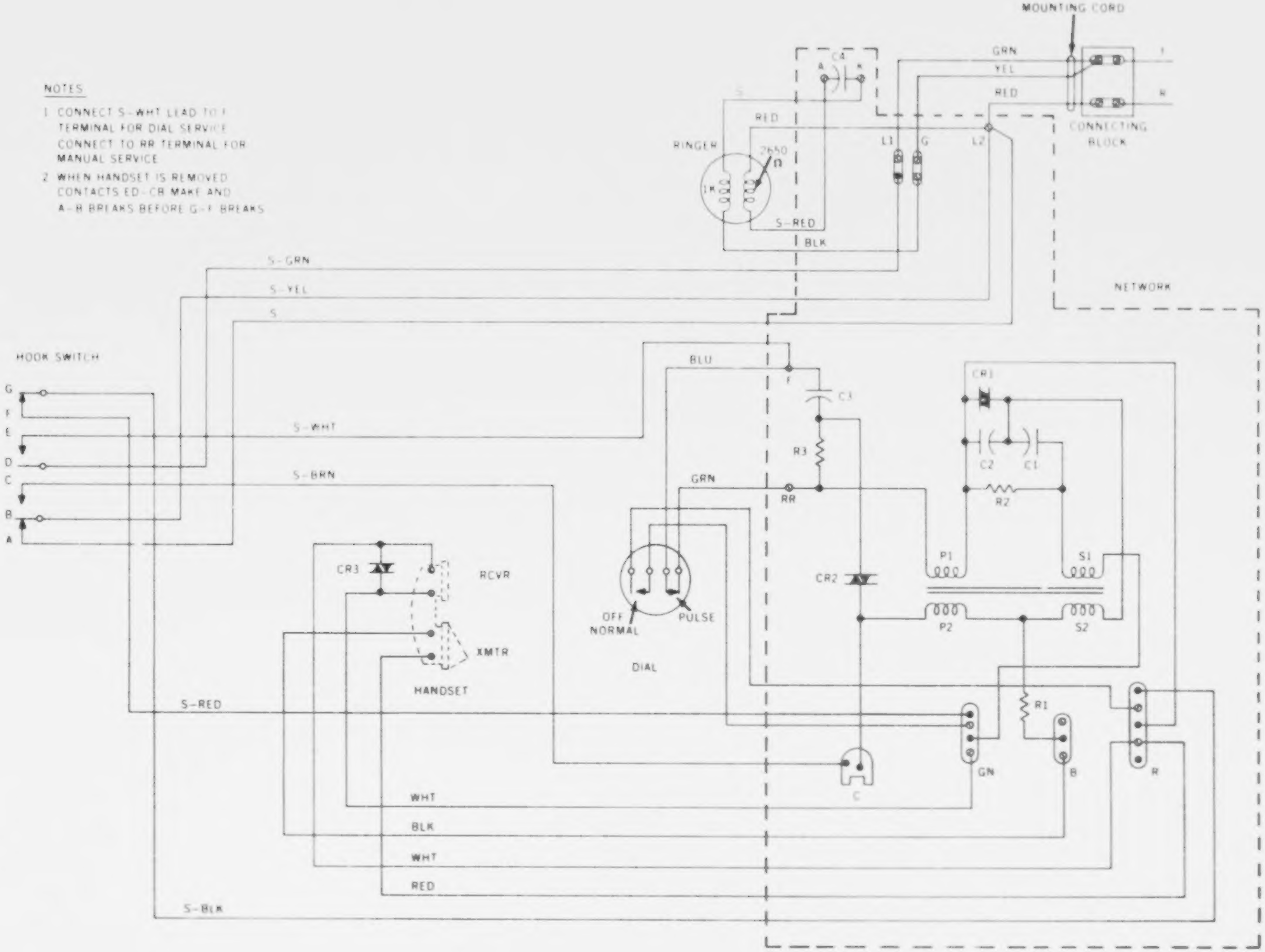

DIAL
SWITCH ARMS
NETWORK
CORD TO HANDSET
RINGER
RINGER LOUDNESS CONTROL
HF-0010

Figure 2–14. Inside view of 500-type telephone.


MOUNTING CORD
GRN
YEL
RED
T
R
CONNECTING BLOCK
C4
A
K
S
RED
RINGER
1K
2650 Ω
S-RED
BLK
L1
G
L2
NETWORK
S-GRN
S-YEL
S
HOOK SWITCH
G
F
E
D
C
B
A
BLU
F
C3
R3
S-WHT
S-BRN
GRN
RR
CR1
C2
C1
R2
P1
S1
P2
S2
CR2
CR3
RCVR
XMTR
HANDSET
OFF NORMAL
PULSE
DIAL
S-RED
R1
C
GN
B
R
WHT
BLK
WHT
RED
S-BLK

NOTES

1 CONNECT S-WHT LEAD TO F TERMINAL FOR DIAL SERVICE CONNECT TO RR TERMINAL FOR MANUAL SERVICE

2 WHEN HANDSET IS REMOVED CONTACTS ED-CB MAKE AND A-B BREAKS BEFORE G-F BREAKS

Figure 2-15. Schematic-wiring diagram for 500-type telephone.

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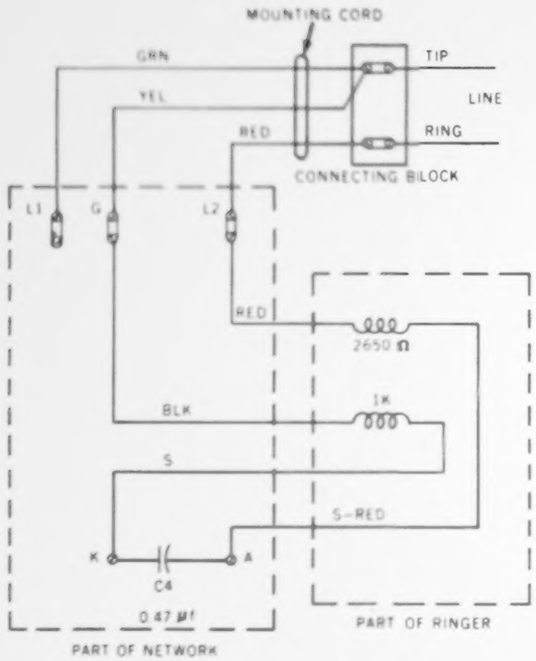


Figure 2-16. Ringer circuit schematic diagram.

4. In figure 2-16, what component attached to network terminals A and K passes the ringing current but blocks DC?

5. What color is the lead that interconnects the ringer and network terminal G?

6. What the color is the lead that terminates at network terminal K and the ringer?

212. Trace the 500 telephone transmitter circuit to identify specific conditions, connections, and units.

Before the transmitting, receiving, or dialing circuits can operate, the handset must be removed from its cradle. If the handset were removed from its cradle on the set illustrated in figure 2-15, hookswitch contacts A-B and F-G would break (open) and contacts B-C and D-E would make (close). Breaking contacts F-G would remove the short from across the receiver, and making contacts B-C and D-E would connect the tip and ring conductors through to the telephone circuitry. Current would flow from the central office to the telephone transmitter via the tip and ring conductors. Let's trace the path of this current through the telephone transmitter circuit in figure 2-17. However, you should have no trouble in tracing the path of current on either figure (2-15 or 2-17).

When the handset is removed from its cradle, allowing the hookswitch to operate, dc from the central office passes over the ring side of the line to the connecting block and then over the red (RED) mounting cord conductor to terminal L2 of the network. From terminal L2, it passes over the slate-yellow (S-YEL) wire to the operated B-C contacts of the hookswitch and then over the slate-brown (S-BRN) conductor to terminal C on the network. From terminal C, it passes through induction coil winding P2, resistor R1, terminal B, through the black (BLK) conductor of the handset cord to the transmitter, and then via the transmitter and red (RED) conductor of the handset cord to terminal R on the network. After the current leaves terminal R, it passes through induction coil winding P1, terminal RR, the green (GRN) wire lead to the dial, the normally closed pulsing contacts, and then via the blue (BLU) wire from the dial to terminal F on the network. From terminal F on the network, the current passes over the slate-white (S-WHT) wire to the operated D-E contacts of the hookswitch, through the contacts and the slate-green (S-GRN) wire to the L1 terminal, and then over the green (GRN) conductor of the mounting cord to the tip side of the line at the connecting block. From this point, the current returns to the positive side of the battery at the central office via the tip side of the line.

Note in figure 2-17 that the transmitter current flows through both primary windings (P1 and P2) of the induction coil. Also note that the current flows through these windings in opposite directions; that is, the current that flows through winding P1 in one direction flows through winding P2 in the opposite direction. Thus, with any current change in the circuit, these windings aid each other through the process of induction. Therefore, when someone speaks into the transmitter, causing its resistance to vary, the changing current values in the circuit cause strong voice currents to be induced in the induction coil windings. These voice currents, beside being applied to the network circuits, are applied to the telephone lines leading to the central office. If these lines are connected through to another telephone, the voice currents are applied to the receiving circuitry of that unit. Before we trace these voice currents through the receiver circuits, let's briefly discuss the equalizing feature of the telephone.

When voice currents are induced in the transmitter circuit, they pass through terminals RR and C of the network assembly. These voice currents are also applied to the tip and ring conductors via the circuitry of the dial, hookswitch, and connecting block assembly (see fig. 2-17). Similarly, when voice currents are received by the telephone, they enter the circuitry over the tip and ring conductors and go through terminals RR and C via the connecting block, hookswitch, and dial circuitry. To keep the speech volume approximately equal at telephone sets located at varying distances from the central office, the telephone is equipped with an equalizer circuit. The equalizer circuit consists of two parallel circuit paths between terminals RR and C. One of these paths is through resistor R3 and varistor CR2 (see fig. 2-17). The other path is through winding P1, varistor CR1, and windings S2 and P2. These circuits tend to lower the volume on the left, and to use red wire for the ring side of the line and green wire for the tip inside a house. This gave rise to an expression frequently used by telephone workers, "RED-RING-RIGHT." The RED wire is the RING conductor and it is connected on the RIGHT. In addition, the RED wire is connected to battery and it is negative in respect to the tip or ground. With this preliminary, general discussion, we've finally got the wiring leading up to the telephone connecting block. Now we're ready to consider the individual 500 telephone circuits, starting with the ringer circuit. Since reading circuit diagrams is so important in telephone repair, try first to answer the following exercises from figure 2-15 alone.

Exercises (210):

1. Which circuit attaches at network terminals G and L2 and consists of two wire coils and capacitor C4?

2. What four circuits use the induction coil windings when they are functioning?

3. What are components CR1 and CR2?

4. What are components C, GN, B and R?

5. What line lead attaches to the connecting block terminal that terminates a red wire from the 500 telephone network?

6. What potential do you expect when you test the connecting block terminal that terminates the yellow and green wires from the telephone network?

211. Give two 500 telephone conditions required for the ringer circuit to operate, and specify the ringing current and circuit parts through which the current passes.

As you study the circuits in figures 2-15 and 16, assume that the conductors are extended from the central office to the telephone connecting block. With the conductors so connected, the central office can extend either battery or ringing current to the telephone. In both figures, the telephone mounting cord extends from terminals of the network to the connecting block. The green (GRN) conductor goes from the tip terminal at the connecting block to the L1 terminal on the network; the yellow (YEL) conductor from the tip terminal to the G terminal on the network; and the red (RED) conductor from the ring terminal on the connecting block to the L2 terminal on the network.

The four ringer leads, as you can also see in both figures, are connected to terminals A, K, G, and L2 on the network. By being so connected, the ringer circuit is always completed to the tip and ring leads. For the central office to apply ringing current only to the ringer, however, the handset must be on its cradle to disconnect the tip and ring leads from the transmitting and receiving circuits. If you will take a close look at the hookswitch contacts in figure 2-15, you can see that contacts B-C and D-E are open. Therefore, the handset is on its cradle and the tip and ring leads are disconnected from the receiving and transmitting circuit. With the hookswitch contacts in this position, the only circuit that is completed to the central office is the ringing circuit. To make this circuit easy to trace, it is shown individually in figure 2-16. As we trace the ringing current through this circuitry, see if you can follow the circuit in both illustrations.

The ringing current applied by the central office is normally an ac voltage of approximately 85 volts with a frequency of about 20 cycles per second. Since the ringing current is ac, it alternates in the circuit, first in one direction and then in the other. For the purpose of following the ringing current, however, let's assume that at the instant we are tracing the circuit the current is leaving the central office on the ring lead and is returning on the tip lead. This ringing current passes from the central office to the connecting block via the ring side of the line and then through the red (RED) conductor of the mounting cord to terminal L2 on the network. From terminal L2, the current passes to the 2650-ohm ringer coil over the red (RED) ringer lead, through the ringer coil and the slate-red (S-RED) ringer lead to terminal A on the network. From terminal A on the network, the current has the effect of passing through capacitor C4 to terminal K. From terminal K, the current passes to the 1000-ohm ringer coil via the slate (S) ringer lead and then through the ringer coil and black (BLK) ringer lead to terminal G on the network. From terminal G, the current passes over the yellow (YEL) mounting cord lead to the tip terminal on the connecting block, and then it returns to the central office over the tip conductor.

Exercises (211):

1. How do you connect the mounting cord conductors to enable the ringer circuit?

2. In what position is the handset when the telephone bells are ringing?

3. Give the voltage and frequency of the ringing current.

148

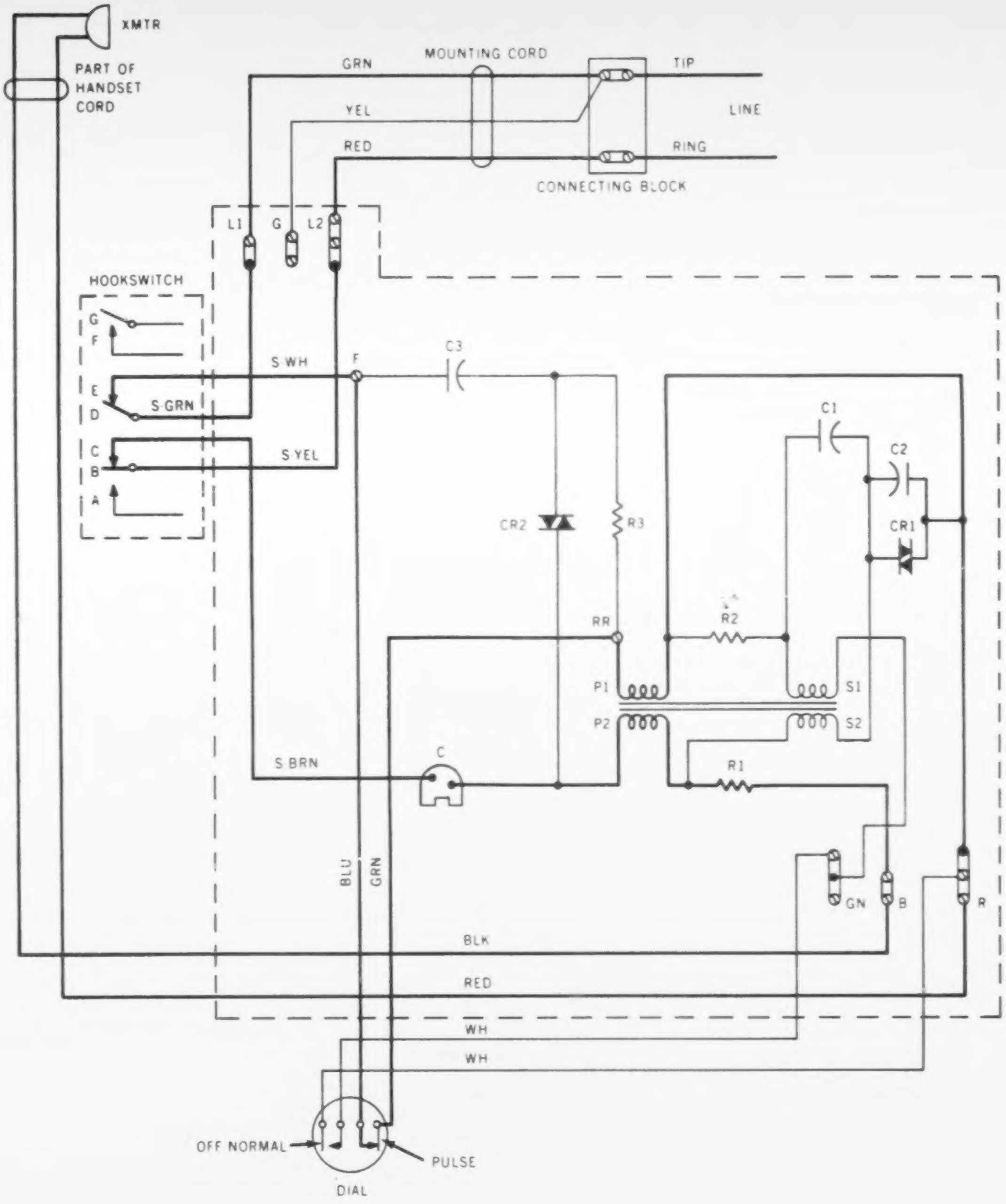

XMTR
PART OF
HANDSET
CORD
GRN
MOUNTING CORD
TIP
YEL
LINE
RED
RING
CONNECTING BLOCK
L1
G
L2
HOOKSWITCH
G
F
E
D
C
B
A
S·WH
F
C3
S·GRN
S·YEL
C1
C2
CR2
R3
CR1
RR
R2
P1
S1
P2
S2
R1
S·BRN
C
BLU
GRN
GN
B
R
BLK
RED
WH
WH
OFF NORMAL
PULSE
DIAL

Figure 2–17. Transmitter circuit schematic diagram (500-type telephone).

when strong voice currents are applied but offer little opposition to the passage of weaker voice currents.

Exercises (212):

Base your answers on figure 2-17.

1. In what position must the 500 telephone handset be to enable the connections shown?

2. Which two units parallel the induction coil primary windings and transmitter?

3. What type of connection does P1 and P2 form?

4. Which unit parallels equalizer varistor CR1?

213. Trace the receiver circuit to identify connections and units.

During a telephone conversation the voice currents from the distant telephone are applied to terminals RR and C on the network (fig. 2-15). These currents pass through windings P1 and P2 in a manner similar to that described for the transmitter circuit. As these varying voice currents pass thorugh windings P1 and P2, they induce an ac voltage in winding S1. This induced voltage causes current to flow to the receiver in the handset.

The induced voltage in winding S1 causes current to flow from one end of the winding to terminal GN and then through a white (WHT) lead in the handset cord to the receiver unit in the handset. From here, it passes through the receiver unit and then to terminal R on the network via another white (WHT) lead in the handset cord. From terminal R on the network, there are four possible paths for the induced current to reach the other end of winding S1:

(1) From terminal R through series-connected capacitors C2 and C1 to winding S1.

(2) From terminal R through resistor R2 to winding S1.

(3) From terminal R through varistor CR1 and capacitor C1 to winding S1.

(4) From terminal R through the red (RED) handset cord lead, the transmitter, the black (BLK) handset cord lead, terminal B, resistor R1, winding S2, and capacitor C1 to winding S1.

As the current from winding S1 passes through the receiver unit, the receiver diaphragm vibrates, producing a sound similar to that entering the transmitter at the distant telephone.

Exercises (213):

1. In figure 2-15, what network terminals complete the receiver circuit?

2. What units are connected in parallel?

214. Trace the antisidetone circuit and specify actions, conditions, and component arrangements that result in or from its operation.

As you know, sidetone refers to the sound that reaches a telephone receiver from the transmitter of the same telephone set. In other words, it has to do with how loud you hear your own voice in the receiver as you speak into the transmitter of your telephone. The antisidetone circuitry reduces the sidetone to a desirable level. In the telephone, sidetone is reduced by the balancing action of the components in the network. To understand this balancing action, you must remember that the network functions in two different ways during an ordinary telephone conversation. When voice currents from the telephone line are applied to terminals RR and C, the network functions as a receiving unit by applying strong voice currents to the receiver. When you speak into the transmitter, the network applies strong voice currents to the line and at the same time reduces the strength of the voice currents to the receiver. Therefore, the antisidetone feature is applied whenever you speak into the transmitter.

The voice currents that enter this subset from the telephone line are applied to terminals RR and C of the network (see figs. 2-15 and 2-17). As these currents pass from terminal C to terminal RR, they pass through winding P2, resistor R1, the transmitter, and winding P1. In addition to this, part of the current that passes through winding P2 flows through winding S2, varistor CR1, and winding P1 to arrive at terminal RR. From this, it is easy to see that the received voice current passes through windings P1, P2, and S2. The voice current that passes through all three of these windings induces an additive voltage in winding S1. Therefore, during receiving, a strong voice current is applied to the receiver unit by winding S1.

When the handset is removed from its cradle and the telephone is ready for use, dc current flows from the central office to the telephone instrument via the telephone lines. This current passes through windings P2, S2, and P1 in going from terminal C on the network to terminal RR. Of course, in doing this, it also passes through resistor R1 and the transmitter, as well as through winding S2 and the varistor CR1. It is important to note that the circuit through resistor R1 and the transmitter is in parallel with the circuit through winding S2 and varistor CR1. Because of this parallel arrangement, any change in transmitter resistance (such as caused by sound waves striking the diaphragm) will cause a change in current through winding S2 that is opposite to the changes in current in windings P1 and P2. For example, a decreasing resistance in the transmitter will increase the current through winding S2. With these current changes in opposite directions, the voltages induced in winding S1 by windings P1 and P2 are 180° out of phase with the voltage induced in winding S1 by winding S2. Thus, during transmission, a cancellation takes place in winding S1, reducing the strength of any induced voice currents in the receiver circuit. Also during transmission, part of the changing current in winding S2 passes through resistor R2. This current develops a voltage across R2 that is out of phase with the voltage induced in winding S1. Therefore, sidetone is further reduced in the receiver circuit.

Exercises (214):

1. What type of action provides the sidetone reduction at the receiver?

2. What circuit condition produces the sidetone reduction?

3. What series-connected components are in parallel for sidetone reduction?

215. State dialing circuit actions and conditions at specified times.

When the handset is removed from its cradle, a dialing circuit is established to the central office via the telephone lines. The completion of this circuit is indicated to the subscriber by the dial tone in the receiver. This dialing circuit is actually the same as the transmitting circuits. Dialing current from the central office passes over the ring side of the line to the telephone connecting block. To trace the dialing circuit from the connecting block through the telephone, refer to figure 2-17. From the ring conductor at the connecting block, the dialing current passes through the red (RED) conductor in the mounting cord to terminal L2 on the network. From terminal L2, it passes over the slate-yellow (S-YEL) lead to contacts B-C on the hookswitch, through the B-C contacts and a slate-brown (S-BRN) lead to terminal C, and then through three parallel paths to terminal RR:

(1) From terminal C through series-connected varistor CR2 and resistor R3 to terminal RR.

(2) From terminal C through the series circuit formed by windings P2 and S2, varistor CR1, and winding P1 to terminal RR.

(3) From terminal C through winding P2, resistor R1, the transmitter and handset conductors to terminal R, and then through winding P1 to terminal RR.

From terminal RR, the dialing current flows over the green (GRN) dial lead to the pulsing contacts on the dial; through the pulsing contacts and the blue (BLU) dial lead to terminal F, through terminal F and the slate-white (S-WHT) lead to contacts D-E on the hookswitch; through the D-E contacts and the slate-green (S-GRN) lead to terminal L; through the green (GRN) mounting cord lead to the tip terminal on the connecting block; and then to the central office via the tip conductor of the telephone line. During dialing, of course, the pulse contacts on the dial open and close the circuit the same number of times as the number of each digit dialed. During the dialing of each digit, the off-normal contacts close, shorting out the receiver circuit via the white (WHT) dial leads. The shorting out of the receiver circuit keeps the subscriber from hearing the dial pulses in his own receiver. Without this feature the dial pulses would be heard as loud clicks in the handset receiver. One more feature of dial operation is that capacitor C3 and resistor R3 form a capacitance resistance bridge across the pulsing contacts of the dial. The bridge circuit protects the pulsing contacts from excessive arcing and burning during dialing.

Exercises (215):

1. Refer to figure 2-17. What has occurred at TIP and RING of the line during the preparation for dialing?

2. What is the first indication to the telephone user that the circuit in figure 2-17 is complete?

3. Dialing the digit 4 results in how many interruptions in the line circuit?

4. What two network components suppress arcing at the dial pulse contacts?

2-6. Other Telephones

The parts and circuits described for the 500 telephone are used in many telephone configurations. Let's mention a few examples of such units.

216. Name four other types of Air Force telephones, and state how they differ from the 500.

Wall telephones, both 554 and 558 series, use the same parts and circuits as the 500 telephone. The main difference between these sets and the 500 unit is in the shape of the base and housing components, which facilitate wall mounting. The 564 and 565 key telephones use the same parts and circuits, as do the 630 and 631 series of call director telephones. If you understand the 500 telephone, you will have little trouble in understanding the operation of these others. Also we must point out that you may become involved with telephones that use the components and circuitry explained in Chapter 1 of this volume.

In addition to these telephones, explosion proof and weatherproof sets are used at some Air Force installations,

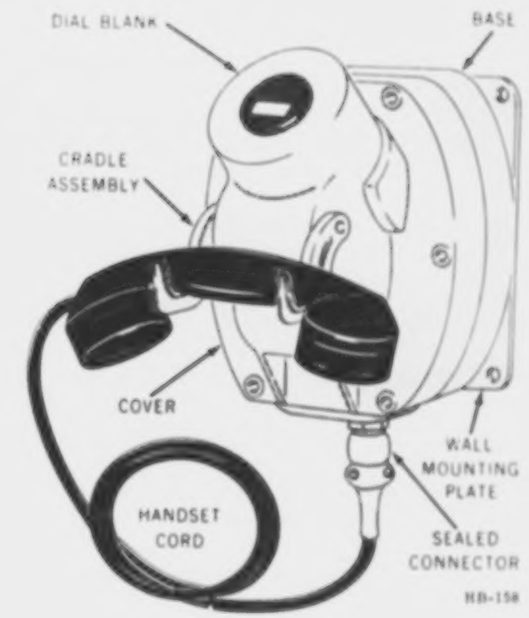


Figure 2-18. Explosionproof wall-type telephone.

especially at missile sites. Explosion proof phones (see fig. 2-18) are used where they may be exposed to combustible gas. Except for the handset, the circuit components are inclosed in a cast aluminum housing to keep electric arcing from igniting fumes or gas in the area. All connections to the set are sealed, and the line wires are placed in a conduit attached to the set by threaded connections, which are also sealed to keep out gas.

At some installations, explosion proof and weatherproof connecting stations are provided. To use this type of station, you just plug in an explosion proof headset and transmitter assembly. When weatherproofing only is required, the subset is normally inclosed in a box or cabinet that is sealed against the entrance of moisture. The internal components of explosion proof and weatherproof telephones are the same as the components used in ordinary telephones, so the principle differences are simply in the explosion proof and weatherproof housings and in the methods used for sealing against the elements.

Exercises (216):

1. Name four telephones similar to the 500-type telephone.

2. What is the difference between the wall and table model telephones?

3. How is a telephone made explosion proof?

4. How is a telephone weatherproofed?

5. How do you make a call from the explosion proof and weatherproof telephones?

CHAPTER 3

Maintenance and Inspection System and Records

MAINTENANCE management is a concept. By applying its principles, we keep Air Force equipment in top operating condition. The primary objective of people in the Air Force maintenance system is to develop and retain the military capability needed to sustain Air Force operations under all conditions—wartime, emergency, and peacetime. Thus, it is obvious that if we are to have both combat effectiveness and economy in mission performance, we must have fast, high-quality, base-level repairs and technical order compliance. Therefore, the Air Force must have personnel who are properly organized, trained, and equipped to support the combat force.

In a military unit, the organization is determined by the mission. Accordingly, maintenance units are organized and equipped for a specific level of maintenance work. AFR 66–1, *Maintenance Management*, contains the guidelines for the organization, operation, and control of the maintenance management system in all Air Force activities. It provides the information used by supervisors at all levels as they develop programs to perform their missions as quickly and economically as possible.

This chapter includes information about the structure of maintenance organizations, the maintenance management program, materiel deficiency reporting system, materiel processing and control, and telephone system records within a communications organization. You must keep in mind that conditions vary. An organization must be able to perform even after changes in plans. Operational conditions are often uncertain. Furthermore, we are here giving only general information about the system. Every organization has problems that apply only to its operation. You can use the basic knowledge that we provide to cope with whatever changes individual units or situations demand.

3-1. Maintenance System

When you consider the thousands of maintenance jobs that must be done and the many people who must do them, it is evident that the Air Force must have an efficient maintenance system. This system has a centralized management to develop the policies and procedures described in AFR 66–1 and in Air Force technical orders (TOs). You know that the objective of maintenance is to keep equipment operating. Obviously, there are many types of equipment designed and used by the Air Force. Thus the system must be flexible, and it is therefore complex.

217. Associate the levels of maintenance within their typical maintenance tasks, and give the responsibilities of the DCM staff.

Air Force maintenance includes (but obviously is not limited to) inspection, repair, overhaul, modification, preservation, testing and analysis. Maintenance is done at three levels: organizational, intermediate or depot.

Organizational Level. AFR 66–1 defines the organizational level of maintenance maintenance is the main responsibility of a using organization on its assigned equipment. It normally consists of inspecting, servicing, lubricating, adjusting and replacing of parts, minor assemblies, and subassemblies. Some organizational maintenance responsibilities may be assigned to equipment operators.

Intermediate Level. This maintenance is normally accomplished by the using command in fixed or mobile shops, but it may be done by specialists dispatched from these shops to a using organization. Since intermediate maintenance also includes repair or replacement of damaged parts and assemblies, it may sometimes seem indistinguishable from organizational maintenance, but it can be more inclusive and can consist of calibrating assemblies, modifying materiel, and emergency manufacture of unavailable parts. Technical assistance from the command to the using organization is also intermediate-level maintenance.

Depot Level. Depot-level maintenance is performed in fixed shops with extensive facilities and equipment or by onsite teams of highly qualified people with technical skill for repair, modification, and manufacturing that the lower levels do not have.

Organizational Structure. AFR 66–1 directs that the officer having authority to manage the CEM organization is the deputy commander for maintenance (DCM). The DCM is assigned to the organizational level and has control of all assigned personnel and equipment. (The DCM was formerly called Chief of Maintenance and the older term is still around.) The DCM plans, organizes, coordinates, directs, and controls the maintenance effort. He or she must be familiar with the construction of the maintenance complex and the organizational arrangement of the staff and the shop personnel, and he must recognize probable maintenance problems. He is directly responsible to the commander.

Of course, you realize that the deputy commander for maintenance has too many responsibilities to manage each action personally. Therefore, the DCM delegates to a staff the authority to supervise many of these functions. We shall mention DCM and DCM staff duties, only briefly here because they are described in detail in AFR 66–1.

The DCM manages by directives, guidance, and coordination, directing subordinate units to comply with AFR 66–1 and with any supplementary operating instructions. In addition, the DCM provides guidance by personal contact, by delegating the necessary authority to the lowest level supervisors, and by publishing maintenance operating instructions (MOIs). The DCM also coordinates with supporting agencies and with users to be sure communications are adequate and equipment is available for the mission.

Figure 3-1 shows the DCM's management units for a typical communications-electronics meteorological (CEM) maintenance organization. This organizational chart shows only one type of functional arrangement, but note the reference for the maintenance supervisor (6). In that structural arrangement, a maintenance supervisor may be required for two or more workcenters; or in some CEM units, several supervisors may be required. The additional units identified with the DCM (on the chart) are quality control, maintenance control, and Minuteman missile cable affairs. However, the DCM function block of the figure shows sections (branches) which also are responsible to the DCM. They are maintenance superintendent, production analysis, training management, administration, and programs mobility. Note that this latter section is authorized only for organizations with a mobile requirement. Let's look briefly at the five sections in the DCM block.

Maintenance superintendent. This position may not be authorized in some organizations. It may be authorized, however, when the DCM is a commissioned officer or equivalent civilian. The superintendent must have management and technical qualifications to support the DCM by advising and assisting in the management of the maintenance program.

Production analysis. To give the DCM and the workcenter supervisors the results of studies and to recommend maintenance actions, production analysis collects maintenance data and studies them for trends and for troublesome areas. Having analyzed the data, the section may summarize the findings, identify the suspected problems, and recommend submission to the deficiency analysis unit, for investigation. The Maintenance Analysis Referral (MAR) form (AF Form 2422) is used to document the problem, the results noted during the investigation, and the recommended solutions. This MAR form also is used to show what is done to overcome the problem. Production analysis files the MAR and all other analysis summaries and study results for future reference. It may also make and keep charts and graphs for furnishing analysis data to the DCM.

Training management. Training management gathers information on maintenance weaknesses and on newly assigned people. Then it determines the training requirements, schedules the training in central locations, and controls the testing for the program. It consolidates all of the training information for future reference. Training management must develop and file training documents. It is responsible for qualification, job proficiency, and special training. Qualification training allows the specialist to develop a greater knowledge and more skill for the assigned position. Of course, the workcenter supervisors are directly responsible for the training. Training management, in turn, assists in developing of the training program and monitors it while it is being conducted. It also monitors job proficiency training, which is a part of on-the-job training, and special training to qualify a specialist on new or modified equipment.

Training management supervises the administration of tests required in the organizational training programs. These tests may be locally or command developed. It analyzes the test results to identify deficient areas and, if necessary, schedule additional training. It monitors the training programs in order to keep the DCM informed about the status of the total maintenance training program. This information usually consists of noted training deficiencies and any additional training scheduled or required because of changes in equipment or additional new equipment.

Administration. The administration section provides accurate, timely reports about the information distributed from the central reporting office and about the authorized personnel and their assignments. This section also keeps functional publications on file for reference. Coordination with the other DCM units is also one of its important responsibilities.

Programs-mobility. The programs-mobility section must know the available resources and the maintenance programs to be supported by the DCM. It plans for and monitors the result in costly bench stock, spare parts, special tools, test equipment, technical so includes coordination with contractors to prevent conflicts that could result in costly contract changes and a delay in program implementation. The program-mobility section also provides documentation to the contracting officer for determining task and support compliance requirements from the contractor. One important requirement to be included in most contracts is a directive for time compliance technical order reporting.

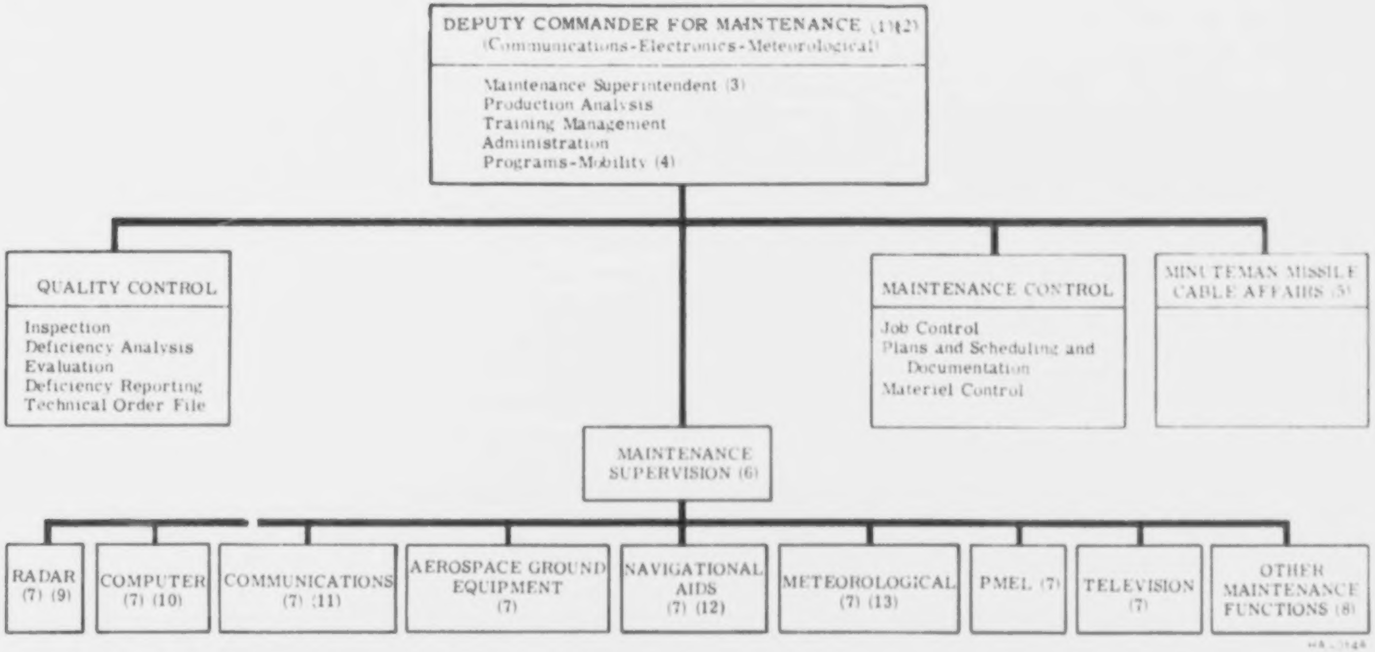
Exercises (217):

1. Name the three levels of maintenance.

2. Most maintenance performed at workcenter Y6720 is what level of maintenance?

3. Replacing a 400D KTU for the 1A2 key system would most likely be what level of maintenance?

4. What level is used in modifying a key system power unit for emergency use?


DEPUTY COMMANDER FOR MAINTENANCE (1)(2)
(Communications-Electronics-Meteorological)
Maintenance Superintendent (3)
Production Analysis
Training Management
Administration
Programs-Mobility (4)
QUALITY CONTROL
Inspection
Deficiency Analysis
Evaluation
Deficiency Reporting
Technical Order File
MAINTENANCE CONTROL
Job Control
Plans and Scheduling and Documentation
Materiel Control
MINUTEMAN MISSILE CABLE AFFAIRS (5)
MAINTENANCE SUPERVISION (6)
RADAR (7) (9)
COMPUTER (7) (10)
COMMUNICATIONS (7) (11)
AEROSPACE GROUND EQUIPMENT (7)
NAVIGATIONAL AIDS (7) (12)
METEOROLOGICAL (7) (13)
PMEL (7)
TELEVISION (7)
OTHER MAINTENANCE FUNCTIONS (8)

(1) Communications-electronics-meteorological equipment maintenance organized as a group, squadron, detachment operating location, division, branch or section based on overall organizational structure and size of the functions.

(2) When a CEM maintenance function is assigned to a technical training center, the activity will be organized under the technical training center chief of maintenance.

(3) When authorized.

(4) Mobility authorized only for units having a mobility requirement.

(5) Authorized only for units supporting Minuteman.

(6) For proper span of control, a maintenance supervisor may be required for two or more workcenters, and in some CEM units, several maintenance supervisors may be required.

(7) Delete or combine functions as necessary depending on size, location, mission, and span of control. Functions authorized as required to support assigned mission.

(8) Additional functions such as telemetry, photographic, photo-optics, instrumentation, AFRTS, training equipment, special maintenance teams, centralized intermediate level maintenance, and laboratory may be added as required to support the assigned mission.

(9) Radar functions may be authorized for equipment, such as, flight facilities radar, ground radar, space radar, and ground bombscoring and directing.

(10) Computer functions may be authorized for equipment, such as, command and control, and automatic data processing equipment.

(11) Communications functions may be authorized for equipment, such as, teletype, cryptographic equipment, automatic switching center equipment, telephone inside plant, telephone outside plant, cable-hardened, cable-nonhardened, space communications systems, radio relay equipment, ground radio, and nontactical radio.

(12) Navigational aids functions may be authorized for equipment, such as, nonradar terminal and enroute flight facilities equipment.

(13) Meteorological functions may be authorized for intermediate level maintenance and organizational level maintenance shops.

Figure 3–1. Communications-Electronics-Meteorological Maintenance organizational chart.

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5. You have some test and communications units that must be calibrated or restructured. What maintenance level does this work?

6. Use figure 3-1 as needed to name the staff positions for the DCM.

7. List the DCM's responsibilities.

8. How does the DCM manage the organization's maintenance?

9. List four duties of the production analysis section.

10. What specific functions must training management consider in preparing its programs?

11. Who files AFR 0-1 and DOD 5200.1-R, *Information Security Program*?

218. Name the quality control functions and associated tasks.

Quality Control. Figure 3-1 shows five quality control functions: inspection, deficiency analysis, evaluation, deficiency reporting, and technical order file. These functions give the DCM the information with which to recognize the quality of the organization's maintenance and to develop standards that ensure efficient, continuous maintenance.

Inspections. The types of quality control inspections are technical, activity, and special. Volume 5 of AFR 66-1, *Maintenance Management (Communications-Electronics Equipment Maintenance)*, explains the objectives of each of these inspections. Therefore, in preparing for such an inspection, read the instructions in this manual. For example, technical inspections must be scheduled to ensure that all equipment is inspected annually. Things quality control may inspect in a technical inspection include operational performance, availability and condition of technical data and test equipment, equipment condition, and safety procedures. Quality control should also recommend probable methods for the supervisor to consider in improving procedures or correcting deficiencies noted during the inspection. Of course, quality control also prepares a report of each inspection. This report identifies the discrepancy as major or minor. A deficiency that prevents equipment from operating or results in an unsafe condition is a major discrepancy. For example, a soldering procedure that blows a power equipment fuse should be labeled a major discrepancy. Conversely, a minor discrepancy does not prevent equipment from performing.

Analyzing problems, determining improvements in methods, and making recommendations are also quality control tasks during the activity and special inspections. The things to be inspected differ, however. To illustrate, during an activity inspection, quality control observes currency and compliance with directives, adequacy of reports and records, quality of management of files, training, evaluations, supply discipline, and general housekeeping procedures. These and the other areas (listed in Volume 5 of AFR 66-1) are inspected in adequate depth so that the conclusion arrived at for the whole activity is complete and accurate. An example of a special inspection is the inspection performed when new or modified equipment is provided. This inspection insures that the equipment meets the technical requirements. Quality control will provide references or a rationale for each discrepancy noted. As with production analysis reports, the quality control inspection reports are sent to deficiency analysis for further study and action.

Deficiency analysis. Again, deficiency analysis studies reports about equipment and maintenance deficiencies, investigates the problems, and determines possible solutions. As a result, it makes recommendations, may demonstrate the improved methods, and helps plan to implement the proposed change. It then follows up the corrective action to determine its adequacy. Deficiency analysis, in turn, provides reports to the DCM summarizing the inspection reports received, giving the status of incomplete investigations and the results of completed investigations, and identifying potential problems that could affect the mission. Of course, these are only example tasks for deficiency analysis.

Evaluation. In addition to the inspection responsibility, quality control personnel also evaluate workcenter personnel to ensure that competent people are providing quality maintenance. The evaluator uses standards developed by quality control.

Some newly assigned specialists to a new type of equipment are evaluated no later than 3 months after the equipment is operational. Each is observed to see that she or he uses the proper procedures and that the completed work meets the established standards. If a worker fails to be certified on a task or on some tasks during the evaluation, a special evaluation is made, (after the worker attends a training program) to determine whether or not he has become qualified at those specific tasks.

An evaluation includes preparation, task performance, and post-performance. The preparation phase includes getting and setting up required tools and equipment in the work area. Also, the evaluator prepares for the evaluation by selecting tasks to be observed, coordinating with the specialist's supervisor, and briefing the specialist (technician) on the selected tasks and the rating criteria. The evaluator observes the task performance of the specialist, compares it with the established procedures, and asks pertinent questions during the performance. After the task performance observation, the evaluator replaces the tools and equipment, checks that the system is again operational, and briefs the specialist on the performance rating. Further, he documents the results of his evaluation.

An evaluation is documented on a form titled Routing and Review of Quality Control Report. It includes blocks for the names of the technicians being evaluated and doing the evaluation. Also, it has the evaluation due date. Further, it has blocks for recommendations and for identifying the task number, for describing the task, and for the evaluator's comments on the performance. This form is signed by the workcenter supervisor, the technician, the trainer, and the quality control supervisor.

Deficiency reporting. Deficient materiel (including publications) is reported as directed by TO 00–35D–54, *USAF Materiel Deficiency Reporting System;* TO 00–5–1, *AF Technical Order System;* and AFR 66–1. Quality control must review this reporting in order to make the program effective. TO 00–35D–54 defines materiel deficiencies which must be reported, illustrates the form used, and gives instructions for making entries on the form. TO 00–5–1 illustrates the AFTO Form 22, Technical Order System Publication Improvement Report and Reply, and has instructions for preparing and submitting it to correct deficiencies in publications. AFR 66–1 illustrates the method for recording these unsatisfactory materiel reports. It is important that equipment repairmen report the deficient materiel, because they know the equipment and know when an unsatisfactory or emergency condition exists.

Deficiency reporting also helps develop local preventive maintenance inspection instructions if PMIs are not available. *NOTE:* Local PMIs cannot be developed to modify or supplement published PMIs. In case of inaccurate or inadequate published instructions, submit the TO improvement report as indicated above.

Technical order file. You know that field technical data is called a library. If quality control (QC) is doing its job properly, it must have a library with current technical data. Thus, the QC personnel must file changes to their technical orders and must monitor to see that these changes are complied with fully. Quality control must also establish a distribution office and the accounts required for all workcenters for which it is responsible. Thus, it will make sure that TO changes and new TOs are provided to these workcenters. Additional commercial and special publications may also be ordered and filed if they apply to the communications workcenter.

Exercises (218):

1. List the five quality control functions.

2. What kinds of inspections does quality control make?

3. List several deficiency analysis tasks.

4. How do we determine whether or not a specialist is performing quality maintenance?

5. How do we correct materiel deficiencies?

219. Name the maintenance control sections and their tasks.

Maintenance Control. Figure 3-1 shows three sections in the maintenance control unit. Job control directs and coordinates maintenance for the workcenters. It plans and schedules maintenance and provides resources for support of the workcenters. The plans and scheduling and documentation section uses the maintenance information from the workcenters and the historical records to figure out future schedules. Materiel control ensures that proper parts, tools, and equipment are available in the required quantities at the proper time. Your study of Volume 5 of AFR 66–1 will show you that the maintenance control unit is a planning, scheduling, coordinating, and controlling center. It may be considered the "hub" around which all other control and production elements operate.

Successful maintenance control depends upon the effective use of maintenance assets and upon the ability to evaluate and use all available information for planning. Five fundamental factors must always be considered in the daily planning and scheduling:

- Priority of work.
- Availability of skilled manpower.
- Availability of materiel.
- Availability of tools and equipment.
- Adequacy and use of facilities.

Job control. You have seen that job control directs maintenance. Volume 5 of AFR 66–1 also tells you how to control the two types of maintenance. To illustrate, you learn that scheduled maintenance requires coordination and monitoring. Also, you use job status documents (JSDs). These documents are also used with unscheduled maintenance. Unscheduled maintenance is often emergency-type repair; therefore, it may require more direct, or commanding, coordination and monitoring than would be used with scheduled maintenance. Minor-fix maintenance is also unscheduled maintenance, but it does not change the equipment status. The equipment will continue to operate while the defect exists. To illustrate, replacement of a controller's position lens in the control tower is a minor-fix action. The lens may be chipped or cracked, but this would not keep the lamp from lighting. Minor-fix actions are not documented on a JSD.

To establish a work priority, job control must know what communications equipment is malfunctioning, the importance of this equipment to the system, and the specialists and maintenance equipment available for use. It should also know probable troubles and test equipment required for locating these faults.

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Job control documents and reports the equipment status to the chief of maintenance, assigning the job control numbers for the documentation and maintaining current files for the forms. Additional records are kept on the inventory of mission-essential end items.

It is job control that keeps a record of the permanently-assigned vehicles and monitors their status. A defective vehicle is reported to the vehicle control officer. Job control is the centralized point for technician dispatch; thus, crewmembers confer with it when working on a job. If additional equipment is needed, job control arranges to get the equipment and sends it out to the crew.

Job control directs and controls equipment cannibalization directed by the DCM. It identifies the end item to be cannibalized, assigns a new job control number for the documentation form, and directs the workcenter to do the work. Also, it tells materiel control of the approval for cannibalization and provides required information to materiel and maintenance control for their use in documenting the action. When the task is completed, job control sends the required documentation to plans and scheduling and documentation.

Job control also documents and processes telephone outage reports and complaints on Government-owned telephone equipment when the central office testboard is unattended. If emergency restoration is required, this staff coordinates and directs the activities that overcome the outage.

Plans and scheduling and documentation. If planning is inadequate, an operation can fail or become more costly. Scheduling results in maximum production, yet it is the result of planning. Documentation is used when people are making plans and developing schedules. Thus, the DCM is better prepared for making decisions when this section does all three of its functions well. An additional duty of the section is forwarding required maintenance AFTO forms to the workcenter. The center, in turn, enters the specified information. The information to enter is described in TO 00–20–2–8, *On-Equipment Maintenance Documentation for Ground Communications-Electronics-Meteorological Equipment* and associated 00–20 series TOs. The documentation forms require ID and serial numbers developed by this section. Contract maintenance coordination is another function of the section.

This function uses the information from job control to develop the maintenance plan. This plan should result in efficient, high-quality maintenance, because it is a schedule of maintenance that is coordinated with all of the affected functions and is updated regularly. The plan is developed for specific periods (for instance, 28 days or multiple-month cycles). Maintenance actions not completed (deviations) are summarized and analyzed for improving the future plan. In this way, then, the communications maintenance deviations are reviewed and possibly rescheduled. The DCM receives the summary each month, at the minimum.

The function also has files for keeping completed job documentation and historical information. Its filed documentation includes time compliance technical orders (modification directives), because this function starts the TCTO processing for the organization. That is, it notifies materiel control of the TCTO action, prepares the required forms, and coordinates with the workcenter to schedule the work.

Materiel Control. Materiel control may consist of four functions: maintenance supply liaison (MSL), reparable processing (RP), mobility support (MS), and organizational supply support. MSL forecasts the supply requirements of the workcenters and follows up to see that the maintenance units are not delayed because they lack supplies. MSL also assists in developing maintenance schedules. RP schedules off-equipment repair and monitors the maintenance in an attempt to reduce repair time. MS coordinates between the mobile maintenance units and the supplies' management branch. Organizational supply supports mobile, self-sufficient units by coordinating equipment transactions for the mobile unit with the host management office. It is the point of contact for the supply transactions. You should now realize that an important responsibility of materiel control is the development of an efficient system for anticipating maintenance unit supply needs, for delivering the supplies at the required time and at the right place, and for monitoring to determine that the items are used and documented. Hence, materiel control must develop a documentation method and a procedure for filing the records and the publications it uses.

Since management of supplies is an important task of this function, the personnel should know supply terms, supply references, supply requisitions and review procedures, and must emphasize supply discipline. Thus, DIFM (due-in from maintenance), AWM (awaiting maintenance), AWP (awaiting parts), XB (an item that can't be repaired and thus is not authorized in the repair cycle stock). ERRC (expendability, recoverability, reparability, category codes), UJC (urgency justification code), bench stock (often-used supply items kept in local bins), red indicator (flag for out-of-stock items), and many similar terms are known by these people. Likewise, materiel control personnel should be familiar with AFM 67–1, *USAF Supply Manual*, and the related supply publications. Sample requisition and review procedures include monitoring bench stock, reviewing the supply transaction files, using the base supply system data cards and control logs, and inspecting tables of allowances. Supply discipline includes using supplies for the intended purpose, continually safeguarding Air Force property, and eliminating hoarding of supplies.

Exercises (219):

1. Name the three maintenance control units.

2. List four job control tasks.

3. What type of maintenance would replacement of a wire clamp be?

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4. What maintenance function originates the organization's maintenance plan?

5. Which maintenance section receives and processes requests for materiel from the servicing organizations?

6. Which materiel control function orders 400D-type KTUs and monitors to see that the order will arrive as scheduled?

7. Which unit monitors to see that spare fuses for the 302 Switching System power van are kept in the proper bin and are in adequate supply?

8. Who emphasizes supply discipline?

220. List typical tasks of the maintenance and workcenter supervisors.

We have stated earlier in this volume that there may be several maintenance supervisors in an organization. Maintenance supervisors are intermediate-level supervisors serving the DCM to insure compliance with maintenance directives by the supervisors at a number of workcenters. They observe the maintenance activities to ensure that the work is adequate, that safety is being stressed, that the maintenance standards are being followed, that the DCM is aware of the maintenance status and problems, and that the workcenter supervisors know their duties and are following the directives.

Workcenter supervisors work with their own people and with quality control, maintenance control, and maintenance supervisors. They must lead their people, provide accurate technical advice, and be good managers of materiel. As leaders, they ensure that tools, equipment, and supplies are available at the proper time; and they practice supply discipline and safety. Further, they act to correct improper procedures promptly; and they tell maintenance control and the maintenance supervisor when the assigned maintenance is beyond the capability of their workcenter. As workers, they assist their technicians in performing maintenance; maintenance control in periodic review of supplies and tables of allowances; and quality control in scheduling evaluations and training, and in keeping TOs accurate and current. Since the range and scope of the workcenter supervisors' responsibilities are very broad, it should be evident that this listing is only a part of what they do.

Exercises (220):

1. What two supervisors are directly above the specialists and monitor their work and note whether or not they follow applicable directives?

2. List three typical maintenance supervisor tasks.

3. List five specific tasks of workcenter supervisors.

221. Identify two important steps in maintenance record processing, information that can be gained from an analysis, and results of such an analysis.

A detailed description of forms processing is included in AFR 66–1. Study it when you learn that you must supervise the collection and submission of maintenance records.

Maintenance Records. You must be sure that the entries you make are accurate, because the information on the submitted form has to be consolidated into a report and analyzed by supervisors. You have learned earlier that this information is sorted and stored by a machine. For best results, provide new information each day. Hence, you must take or send your completed records to the data services unit at a specified time. When the workcenter supervisor has made certain that the input information is accurate and has submitted it as specified, a report is printed, permitting the supervisors then to analyze and determine maintenance trends, component weaknesses, and labor excesses.

Maintenance information analysis makes it possible for the DCM to spot components with high failure rates and to foretell probable future troubles. Further, the DCM can predict equipment that will need to be ordered and forecast the number of workers required in the workcenters. Study of records should show the time spent on useful work (repair, inspecting, testing, etc). Because this study indicates the number of hours that personnel are loaned to other workcenters and time spent in traveling to and from the workcenter, it may reveal that workers are improperly assigned or that more may need to be assigned to a short-handed workcenter or fewer to a second workcenter. Thus, supevisors may need to change crews to get a good, even, dependable output in work. The study of man-hours should reveal an average time. This average time then becomes a standard in guiding planners and supervisors in their future work.

Devices that fail are often disclosed during the study of the reports. The failure may be due to a lack of quality control rather than a fault in the component. The answer comes from comparing reports from many organizations that have the same equipment. Identifying equipment that may be future trouble permits analysis and modification of it. Accompany any request for modification with a suggestion or

recommendation for improvement, and send the request to **the proper authorities** through prescribed channels.

Exercises (221):

1. Identify two steps in maintenance record processing.

2. List information that can be gotten from an analysis of maintenance records.

3. Cite two benefits of maintenance record analysis.

222. Cite materiel deficiency reporting procedures and state what goes on the report.

Materiel Deficiency Reports. We have seen that the component discrepancy report reveals deficient materiel to management. TO 00–35D–54 covers types of deficiencies to be reported as well as conditions, equipment, etc, not to be reported. Nonemergency deficiencies (category II) on non-work-unit-coded items are reported in a Quality Deficiency Report (SF 368). This mail form covers critical defects (those that may prevent equipment from functioning), major defects (those that may reduce the performance of the equipment), and minor defects (those that have little bearing on equipment operation). Emergency deficiencies (category I) are transmitted electrically using DD Form 173, Joint Messageform.

The person discovering the deficiency prepares the report. The information must be accurate and written in simple language. We are not illustrating the form because forms and dates of forms change constantly. Also, the blocks for the form are self-explanatory. Included as required information are:

a. TO (screening point).
b. FROM (originating point).
c. Date of report.
d. Manufacturer.
e. Manufacturer part number.
f. Number of items defective.
g. Number of items inspected.
h. Number of items in stock.
i. Stock number of item.
j. Whether item is in warranty.
k. Description of difficulty.
l. Cause of difficulty.
m. Action taken.
n. Recommendations.

Quality control submits the deficiency report to the DCM for review, assigns a number to it, and enters the information in the Technical Order Improvement or Unsatisfactory Materiel Reports Log. The reviewers of the report must acknowledge its receipt with another report within 30 days of its receipt.

Corrective actions should be coordinated through quality control and started immediately for the undesirable performances. Good management is action based on facts, whether the facts are good or bad. An organization deserving a compliment should get a "pat on the back," whereas an organization needing to improve should be told how it can improve. Maintenance methods are standardized through analysis of experiences. There is no assurance that what is now considered best cannot be improved. With an effective inspection system, accurate analyses, and up-to-date reporting, you can simplify maintenance procedures. In addition, you can reduce time requirements. The best results come when current and correct information is acted upon immediately.

Exercises (222):

1. On what form should you report a recurring deficiency in the transistor amplifier assembly for the K400D line unit?

2. On what form should you report a category I deficiency?

3. List five information blocks of the materiel deficiency report.

3-3. Telephone Plant Records

Without accurate records, an Air Force maintenance organization will not complete its mission. A successful organization uses these records to learn what procedures have been used and what conditions exist in the installed telephone equipment. Most records are standardized so that a person transferring from one organization to another can read and interpret the entries to the records without difficulty. Standardization reduces the possibility of errors and the time required for maintaining the records.

223. Identify two telephone plant records and cite information used in completing each of them.

ALthough you may use only a few telephone plant records, you should recognize that there are many such records. AFM 100–22, *Management of Base Communications Facilities and Services*, identifies and describes the use of the Local Communications Service Request, the Local Communications Service Order, the Request for FTS Communications Service, and others. Additional records are described in TO 00–20–2–8, *On-Equipment Maintenance Documentation for Ground Communications-ElectronicsMeteorological Equipment*. For this review of telephone plant records, we shall look only at samples of a Local Communications Service Order and a Telephone Equipment Key Systems Record/Worksheet.

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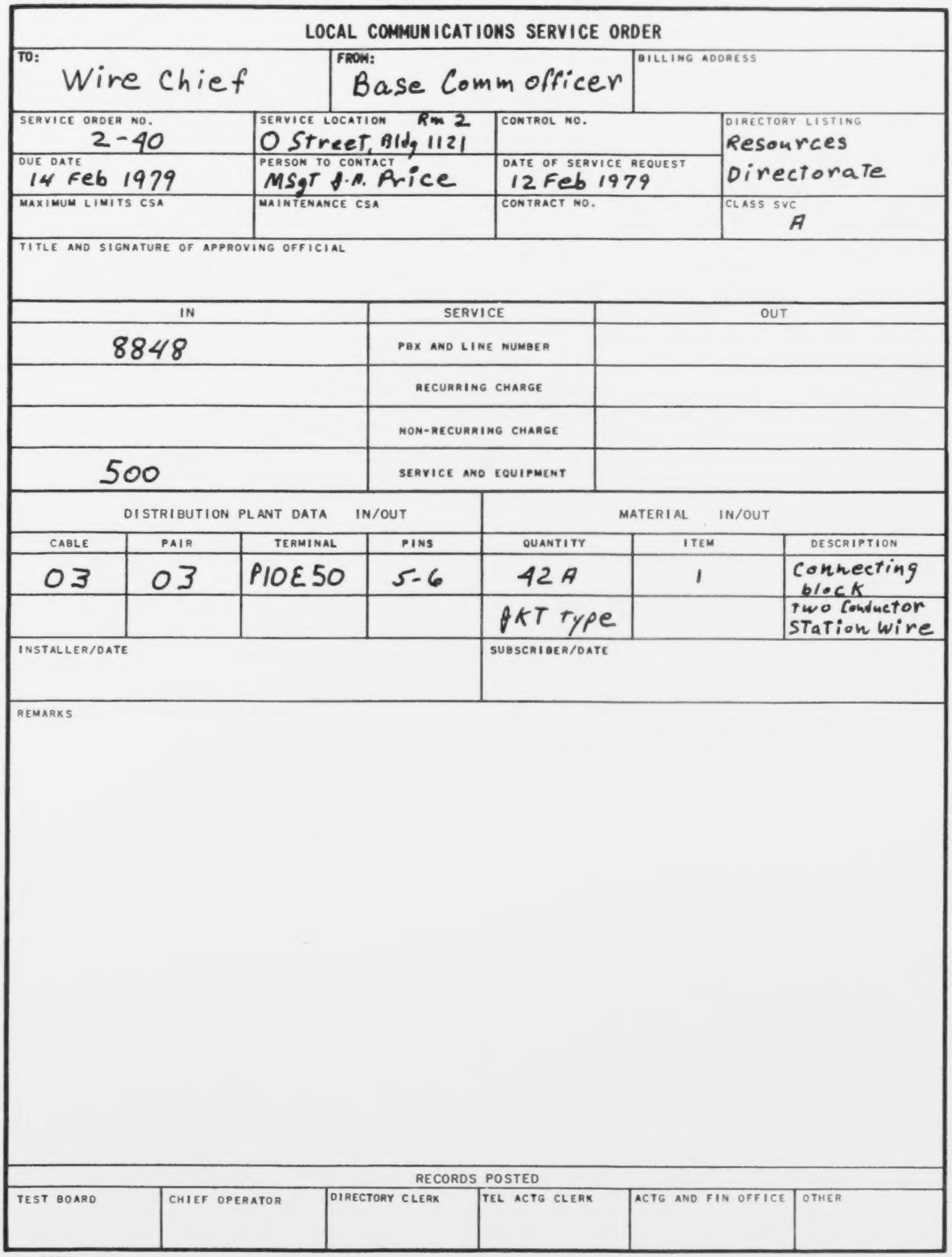


LOCAL COMMUNICATIONS SERVICE ORDER

TO: Wire Chief	FROM: Base Comm officer	BILLING ADDRESS

SERVICE ORDER NO. 2-40	SERVICE LOCATION Rm 2 O Street, Bldg 1121	CONTROL NO.	DIRECTORY LISTING Resources Directorate
DUE DATE 14 Feb 1979	PERSON TO CONTACT MSgT J.A. Price	DATE OF SERVICE REQUEST 12 Feb 1979	
MAXIMUM LIMITS CSA	MAINTENANCE CSA	CONTRACT NO.	CLASS SVC A

TITLE AND SIGNATURE OF APPROVING OFFICIAL

IN	SERVICE	OUT
8848	PBX AND LINE NUMBER	
	RECURRING CHARGE	
	NON-RECURRING CHARGE	
500	SERVICE AND EQUIPMENT	

DISTRIBUTION PLANT DATA IN/OUT				MATERIAL IN/OUT		
CABLE	PAIR	TERMINAL	PINS	QUANTITY	ITEM	DESCRIPTION
03	03	P10E50	5-6	42A	1	Connecting block
				JKT type		Two Conductor Station wire

INSTALLER/DATE	SUBSCRIBER/DATE

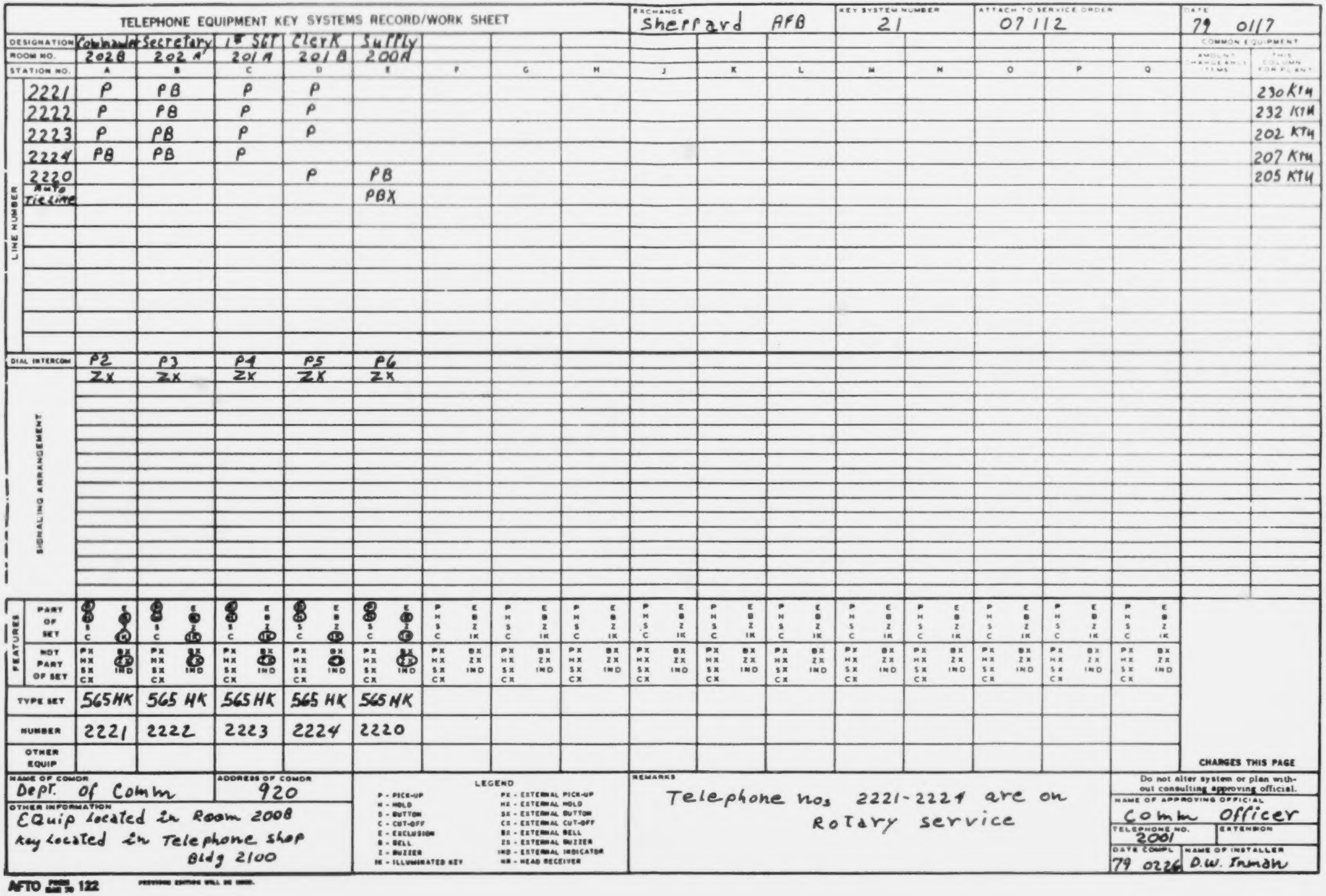
REMARKS

RECORDS POSTED

TEST BOARD	CHIEF OPERATOR	DIRECTORY CLERK	TEL ACTG CLERK	ACTG AND FIN OFFICE	OTHER

AF FORM FEB 72 1075 PREVIOUS EDITION WILL BE USED.

Figure 3–2. Example of a Local Communications Service Order.



TELEPHONE EQUIPMENT KEY SYSTEMS RECORD/WORK SHEET

EXCHANGE: Sherpard AFB
KEY SYSTEM NUMBER: 21
ATTACH TO SERVICE ORDER: 07 112
DATE: 79 0117

		A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	COMMON EQUIPMENT AMOUNT CHANGEABLE ITEMS	THIS COLUMN FOR PLANT
DESIGNATION		Commander	Secretary	1st SGT	Clerk	Supply													
ROOM NO.		202B	202 A	201 A	201 B	200A													
LINE NUMBER	2221	P	PB	P	P														230 KTH
	2222	P	PB	P	P														232 KTH
	2223	P	PB	P	P														202 KTH
	2224	PB	PB	P															207 KTH
	2220				P	PB													205 KTH
	Auto Tie Line					PBX													
DIAL INTERCOM		P2 ZX	P3 ZX	P4 ZX	P5 ZX	P6 ZX													
SIGNALING ARRANGEMENT																			
FEATURES: PART OF SET		[✓ P] [✓ H] S C E [✓ B] Z [✓ IK]	[✓ P] [✓ H] S C E [✓ B] Z [✓ IK]	[✓ P] [✓ H] S C E B Z [✓ IK]	[✓ P] [✓ H] S C E B Z [✓ IK]	[✓ P] [✓ H] S C E [✓ B] Z [✓ IK]	P H S C E B Z IK	P H S C E B Z IK	P H S C E B Z IK	P H S C E B Z IK	P H S C E B Z IK	P H S C E B Z IK	P H S C E B Z IK	P H S C E B Z IK	P H S C E B Z IK	P H S C E B Z IK	P H S C E B Z IK		
FEATURES: NOT PART OF SET		PX HX SX CX BX [✓ ZX] IND	PX HX SX CX BX [✓ ZX] IND	PX HX SX CX BX [✓ ZX] IND	PX HX SX CX BX [✓ ZX] IND	PX HX SX CX BX [✓ ZX] IND	PX HX SX CX BX ZX IND	PX HX SX CX BX ZX IND	PX HX SX CX BX ZX IND	PX HX SX CX BX ZX IND	PX HX SX CX BX ZX IND	PX HX SX CX BX ZX IND	PX HX SX CX BX ZX IND	PX HX SX CX BX ZX IND	PX HX SX CX BX ZX IND	PX HX SX CX BX ZX IND	PX HX SX CX BX ZX IND		
TYPE SET		565HK	565 HK	565HK	565 HK	565HK													
NUMBER		2221	2222	2223	2224	2220													
OTHER EQUIP																		CHARGES THIS PAGE	

NAME OF COMDR: Dept. of Comm
ADDRESS OF COMDR: 920

OTHER INFORMATION:
EQuip located in Room 200B
Key Located in Telephone shop
Bldg 2100

LEGEND

P - PICK-UP	PX - EXTERNAL PICK-UP
H - HOLD	HX - EXTERNAL HOLD
S - BUTTON	SX - EXTERNAL BUTTON
C - CUT-OFF	CX - EXTERNAL CUT-OFF
E - EXCLUSION	BX - EXTERNAL BELL
B - BELL	ZX - EXTERNAL BUZZER
Z - BUZZER	IND - EXTERNAL INDICATOR
IK - ILLUMINATED KEY	HR - HEAD RECEIVER

REMARKS: Telephone nos 2221-2224 are on Rotary service

Do not alter system or plan without consulting approving official.

NAME OF APPROVING OFFICIAL: Comm Officer
TELEPHONE NO.: 2001
EXTENSION:
DATE COMPL: 79 0226
NAME OF INSTALLER: D.W. Inman

AFTO FORM MAR 70 122 PREVIOUS EDITION WILL BE USED.

Figure 3–3. Example of a Telephone Equipment Key Systems Record/Worksheet.

Local Communications Service Order. You learned in the resident course that this Air Force form identifies the telephone to be installed, the cable connections for the telephone, the location where you are to install it, the date for installing it, and service information for it. Figure 3-2 enables us to review such information on a form. On the sample form, you can see that you're to install a 500-type telephone in room 2 of building 1121. Also you're to connect this telephone to pins 5 and 6 at terminal P10E50. Before making the connection, you must check pair 03 of cable 03 to determine whether the circuit is good. The followup operational check must determine that this phone has access to all trunks, since it has class A service. You, the installer, must list the items of material; for example, the 42A connecting block and the two-conductor station wire.

Telephone Equipment Key System Record/Worksheet. You were told in the resident course that this AFTO form is used as a worksheet during the installation of a key system. Then you file it for a record of the installed system. Figure 3-3 allows us to look again at a sample form. As an installer, you can determine the number and types of KTUs and the number and types of keysets you must provide for the system. To illustrate, a 230, 232, 207, 205, and 202 KTU must be installed. Of course, they are installed with the required associate equipment. Likewise, five 565 HK keysets are required. In addition, you can identify the features you're to provide each of these keysets. For instance, the keyset at station 2223 must have the pick-up, hold, illuminated key, and external buzzer features. *NOTE:* The encircled codes identify the features to provide. Since P2 through P6 is shown in the DIAL INTERCOM horizontal blocks and under each of the designated personnel, we recognize that each keyset must have intercom privileges and the signaling that permits it. Most of the remaining blocks are self-explanatory. The remarks block may need some explanation. In other words, the four keysets, 2221-2224, are connected with rotary switching equipment that permits dial selections, whereas the supply keyset does not have this provision. It is tied to a switchboard that is signaled automatically when the handset is lifted.

Exercises (223):

1. What record is your authority for installing a telephone for a customer?

2. What record specifies the keysets required for an office and the features to be provided?

3. List two types of information to note on the 1075 service order.

4. Identify two features you should note on the illustrated AFTO Form 122 worksheet.

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Wire Maintenance Safety

SAFETY PEOPLE have been striving for years to prevent accidents. Yet, although accident rates and the severity of losses may go down every year, safety programs must continue to be emphasized, because someone always loses from an accident and everyone profits from a successful program.

More progress has been made on making machines and equipment safe than has been made in getting people to work safely. You have heard before that the "nut on the steering wheel seldom comes loose; it's the nut at the steering wheel who causes the accident." Well, the human factor is still the big problem. Accidents are caused; they don't "just happen." The identification, isolation, and control of accident causes are the underlying principles of all accident prevention techniques. When you get all of the facts, you can even argue that accidents are avoidable— yes, even when a natural phenomenon is given as a reason.

Accidents are preventable. Nevertheless, many persons through either ignorance or misunderstanding believe that accidents are the inevitable result of unchangeable circumstances or fate. Not only is the belief false, but it also is illogical, because it fails to consider the cause and effect factors present. Common courtesy to others is one simple method for preventing accidents. However, usually, people are hazards to themselves and to others when they fail to comply with safety standards. Thus strict enforcement of safety practices is necessary, backed by prompt corrective action when unsafe acts are seen.

We stated above that people are hazards, yet there are other hazards. Examples of hazards will be identified in this chapter and we shall also mention some precautions that relate to them. In addition, the chapter has information about ladders and climbing equipment and about tools that you will work with.

4-1. Prevention and Reporting Accidents and Hazards.

Each telephone installation and repair specialist must learn the specific hazards that relate to the job. Knowing the hazards, he or she should then be able to offset them. Hazards have been categorized according to severity of their effects in an effort to recognize and correct the most serious ones first.

224. State the 4 hazard categories and give an example for each.

Hazard Categories. Although there are four hazard categories and many hazards included in each category, you should realize that your work will not involve you in all of them. The four categories are: catastrophic (I), critical (II), marginal (III), and negligible (IV).

Catastrophic hazards. A catastrophic hazard may cause death, a critical system loss, or loss of a major facility. You have concern with this category because you may work with an electrical circuit. The danger of the circuit is removed if you disconnect the power before beginning work near or on the circuit. Another probable example is pole climbing. Failure to follow the proper procedures and carelessness have resulted in death to pole climbers. Therefore, always think "Safety" when working in this area.

Critical hazards. A critical hazard may result in a severe injury or illness to the worker, or it may result in major damage to property. Pole climbing may be listed in this category rather than category I, because more severe injuries have occurred than have deaths. Hence, it is a judgment decision as to which category pole climbing should be in. Remember, too, that not all injuries to pole climbers occur on the pole: many people have slipped from the truck while wearing the equipment or have jabbed themselves with the gaff while walking. You might call "falling tools" a critical hazard, because dropping a tool from the top of a pole could cause a severe injury if it hits a worker on the ground.

Marginal hazards. Following the reasoning used with the first two categories, you should realize that marginal hazards may cause minor injuries to workers or minor damage to equipment or property. Failing to keep your work area clean is probably the most prevailing cause for minor injury. Many tools may be considered marginal hazards because of their design and use. For example, a hammer has a head that can smash whatever object it strikes or that may come off while being used. A screwdriver has a sharp edge that may cut or puncture someone or something if it slips.

Negligible hazards. A category IV hazard usually does not affect the workers' health or result in damage. It is a work area problem that violates a specified criterion. To illustrate, failure to post the visual aids that describe the occupational safety and health programs on the work area bulletin board is a negligible hazard. In addition, failure to have hazard reports available for the workers is a category IV hazard.

Exercises (224):

1. Identify the most dangerous hazard category.

2. Give an example of a work area condition that falls in that category.

3. Identify the second hazard category.

4. Identify a telephone installer task that may be considered a critical hazard.

5. Name the two least dangerous hazard categories.

6. Identify a device that a telephone repair specialist uses that may be a category III hazard.

7. Mention a category IV hazard.

225. State typical safety precautions for hazardous situations.

A limited number of precautions are mentioned here because many are described in detail in future chapters when we discuss the work situations themselves.

Tools and Equipment. Regarding live circuits, wise maintenance workers treat energized electrical circuits with respect and caution. They do not use high-voltage equipment without knowing exactly what is to be done. Avoid equipment marked "DANGER—HIGH VOLTAGE" unless you have been authorized to control it. Even then, handle it with care. For example, wear electrical safety gloves designed for the voltage with which you are going to work. A person who attempts to repair electrical equipment without switching off the power is gambling with death.

Safety devices should never by bypassed or modified without authorization. A blown fuse must be replaced with another fuse of the same current and voltage rating. Have good lighting when you are working with electrical equipment. Use insulating matting on the floor next to high-voltage equipment, such as repair and test benches. Use care that you do not let metallic chips, loose solder, or small parts fall on the matting. This metal will, in time, reduce the insulating value of the matting.

Do not work alone on or near *high voltage*. Station a helper where he can see you and where he can reach the main switch quickly in case of an emergency. *(NOTE: All personnel should know the proper treatment for electrical shock.)* Remove your jewelry before you work on this equipment. Keep your clothing closed so that zippers, etc. cannot contact a high-voltage terminal.

A sample of tool safety precautions are: never hold tools such as drills and screwdrivers at an angle. To keep from breaking them, hold them upright. For the same reason, don't twist them with a pair of pliers or pry with them. Do not hold drills in one position until the bit is overheated. Excess heat weakens the metal. Move it in against the object and then pull it back to let it cool momentarily.

Do not use pliers on a nut because you will ruin the nut. This practice may also strip the plier jaws. You will break pliers if you use them as a bar for prying against objects. Use a minimum of strength when twisting pliers to adjust relay components because excessive strength can break the components. "Light fingers" are required when you use all relay adjusting tools.

Always pull wrenches toward you and use the right size wrench to prevent damage to the nut and to your knuckles. Never use a pipe to extend the wrench handle for more leverage. The extra pressure on the jaws may break the wrench.

Never cut into nails with a saw. Also, do not twist a saw to slip off strips of waste material. Doing so may warp the blade or bend the teeth.

Place a canvas or some type of "catchbasket" between a high-level work area and the operating equipment below before beginning to solder or use tools. Take care that your work is done at a safe speed and that you don't overstretch. Otherwise, the work may be of poor quality, or you may fall from your position.

Ladders and Poles. Although there are several types of ladders that you may use, the precautions for all are the same. There are extension ladders (wood and metal), fixed and portable, and A-type ladders. Everybody knows that you shouldn't walk under a ladder, but have you ever done it just to prove to yourself that you could do it without getting hurt? It's also taken for granted that most folks know *not* to stand on the top step of a ladder, but if you watch, you'll see it being done. Some people also try to save time by not moving a ladder; they lean just a little farther to reach what they want. By doing this sort of thing, not only are they likely to get hurt, but they become statistics, their supervisors must fill out a ream of paperwork, and the ground safety people get upset.

But there are still other aspects of ladder and pole-climbing safety. Have you ever dropped anything from a ladder? Think carefully as you prepare to answer that question. Each of us has! And if no one was hurt, we were lucky. Keep this in mind when others are working below you on a job.

To prevent accidents with extension ladders, do not extend them beyond the safety limit. To illustrate, a 45-foot extension ladder must have the sections overlap at least 4 feet. Never use a portable metal ladder where it could contact an electrical circuit. Lash ladders to nearby supports, when necessary, to ensure stability. Make sure that ladder steps are sound and offer good footing. Also, place the ladder with the foot approximately one-quarter of its length away from the building. Never lean a ladder against loose footing. Do not stand higher than the third rung from the top. When you carry a ladder be careful not to strike other workers nor to damage windows or other property.

Inspect pole steps for burrs, 9–10-inch separation, and a 55° to 60° horizontal slope. Never try to climb them when they and the pole are coated with ice. Only one worker should ascend or descend at the same time. Always climb one step at a time, and insure a firm footing before lifting the lower foot from contact with the step. Pole steps are unsafe with wires, cords, rope and climbing equipment hanging on them.

Exercises (225):

1. What protective clothing do you use in installing telephone equipment near a high voltage circuit?

2. Tell the safety requirement for all workers in the vicinity of a live circuit.

3. Give two safety procedures to use with screwdrivers.

4. In tightening a nut, should you use a pair of pliers or a wrench? Why?

5. State the characteristic of a good repair specialist.

6. Cite two very likely ladder safety violations for telephone installers and tell how these violations can be prevented.

7. Give the proper stepping distance when climbing a telephone pole with steps.

8. Tell two unsafe pole step conditions to look for when preparing to ascend a telephone pole.

226. Cite special hazards and precautions associated with live electrical circuits, and indicate the role of an observer during electrical work.

Live Circuit Hazards and Safety Precautions. You learned in your resident course to use caution in working around electrical equipment, because you can never determine whether a conductor is "hot" by looking at it. You also learned that a current-carrying conductor has three factors: (1) voltage, (2) current, and (3) resistance. Although current is considered the killer when a person is electrically shocked, voltage is the pressure that pushes this current.

The possibility of injury to personnel, the danger of fire, and possible damage to equipment are all especially great during maintenance on or around electrical equipment. Maintenance should be performed only by authorized and assigned persons. In those cases where a directive or the commander authorizes you to repair high-voltage equipment, do not start the work until a qualified safety observer is present.

When preparing to repair electrical equipment, turn off the main supply switches, if possible. This includes switches in each circuit from which power could possibly be fed. Keep the covers of fuse boxes and junction boxes securely closed when you aren't actually working in the boxes. Never disconnect such safety devices, as interlocks, overload relays, and fuses, except to replace them. Never change or modify safety or protective devices in any way without specific authorization. Remove and replace fuses only after the circuit has been deenergized. Replace a blown fuse only with a fuse of the same current and voltage rating. When possible, carefully check the circuit and clear the fault that blew the fuse before you replace the fuse.

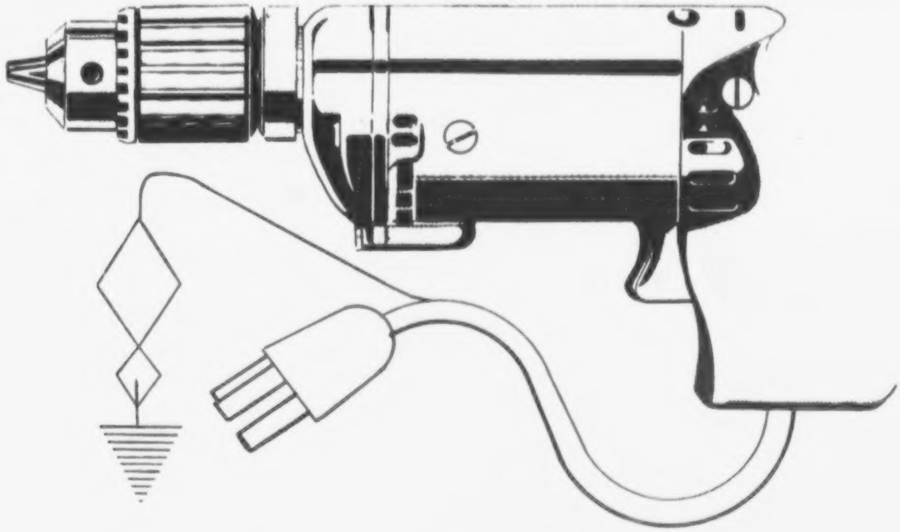
Never work alone near high-voltage equipment. Even very high body resistance and the resistance offered by protective clothing and equipment can be offset by high voltages. Never use tools with metal parts near high-voltage circuits or equipment. You should use only approved insulated tools or rubber gloves, but don't trust them fully. Use warning signs and suitable guards to keep others from coming into accidental contact with high voltages and *heed these warning signs yourself.*

Do not work on electrical equipment with wet hands or while wearing wet clothing; both conditions reduce body resistance. Wearing thin-soled shoes with metal plates or hobnails is also unwise. Wear approved safety shoes with nonconducting soles, if available. Don't wear flammable articles, such as celluloid cap visors. Also, before working on electrical apparatus, remove all rings, wristwatches, bracelets, dogtags, and similar metal items. Take care that your clothing does not contain exposed zippers, metal buttons, or any type of metal fasteners.

Most portable tools have ground wires and standard 3-prong ground plugs (fig. 4-1) to protect you in the event of a short circuit within the equipment. Never defeat the purpose of this connection by cutting or breaking off the ground prong. This might easily result in a fatal shock.

Let's summarize some of the more important "do's" and "don'ts" of electrical safety. Only those who are fully qualified should work on electrical equipment. If you do so, you must be thoroughly familiar with the circuits and must be safety-conscious at all times. You should work on an energized circuit only when it is absolutely necessary. You must use the proper safety equipment, but don't trust it; take the necessary precautions to ensure complete protection against electrical shock. Remember, electricity always conforms to physical laws. You must treat it with the proper respect; otherwise, your experience in this career field may suddenly be terminated.

STANDARDS FOR ELECTRIC POWER TOOLS



1. Use only the tools that are in good working condition.

2. Make sure the tool is grounded properly.

3. Use tools only for the purpose or purposes they are designed for.

4. Report any defects.

5. Wear any necessary protective clothing or equipment.

6. Maintain them in good condition.

7. Do not use them around flammable vapors unless they are designed for such usage.

8. Store them properly when not in use.

Figure 4–1.

Effects of Electricity on the Human Body. Electrical shock may cause instant death or may cause unconsciousness, cessation of breathing, and burns of all degrees. If a 60-Hertz alternating current is passed through a person from hand to hand or from hand to foot, the effects when current is gradually increased from zero are as follows:

a. At about 1 milliampere (0.001 ampere), the shock can be felt.

b. At about 10 milliamperes (0.010 ampere), the shock is severe enough to paralyze muscles so that a person is unable to release the conductor.

c. At about 100 milliamperes (0.100 ampere), the shock is fatal if it lasts for 1 second or longer.

It is important to remember that the severity of electrical shock is largely determined by the amount of current that passes through the body or a portion of the body and, furthermore, that the current flow in a circuit (through the body in the case of a shock victim) is determined by the resistance of the circuit and the amount of voltage applied. You should also remember that the resistance of the human body is not great enough to prevent fatal shock from a voltage as low as 115 volts. In many cases, voltages less than 115 volts are fatal. When the skin is dry, it has a high resistance. The resistance may be high enough to protect a person from fatal shock even if one hand touches the chassis or another ground. However, contact resistance decreases when the skin is moist, and the body resistance may drop to as low as 300 ohms. With this low resistance, a very low voltage could supply enough current to cause death.

Working With an Observer. As we mentioned earlier, in those cases where you must work near or with equipment with high-voltage potentials, make sure that the work is authorized by applicable directives and/or with the approval of the commander. Do not start working until a qualified safety observer is present. The safety observer must be prepared to disconnect the power immediately in the event of an accident. All safety observers must be trained in the techniques of first aid for electrical shock. Their primary responsibilities are:

a. To enforce safety precautions.

b. To know, and be capable of using, emergency first-aid treatment, including artificial respiration and closed-chest heart massage.

c. To let no one approach the equipment without first giving positive warning of the potential dangers.

d. To stand where they can plainly see all personnel working on the equipment and where they can easily reach the main power switch in an emergency.

e. To immediately disconnect the power source at the first sign of an emergency or accident.

Exercises (226):

1. List three possible results of unsafe maintenance acts around electrical items.

2. Give three general-type electrical safety procedures.

3. What special precautions should you take when you use hand tools near electrical circuits?

4. What must you always check before using any electrical tool?

5. What is the effect when you receive 10 milliamperes of current?

6. State two things a safety observer must know.

7. Tell two safety procedures a safety observer must enforce.

227. State how to report accidents and safety violations.

Accident Reporting. It should now be evident to you that even with all of the safety information and training programs provided, someone will use unsafe procedures and cause an accident. As a result, an accident report must be completed and submitted. Proper reporting is important, because it shows what facts have been discovered and how comprehensive the investigation has been. This evidence may reveal the way to prevent a recurrence. Obviously, a single accident report may not show the changes that are needed; this may require many accurate reports and many attempts at corrective action.

AFR 127–4,*Investigating and Reporting US Air Force Mishaps*, governs accident reports. According to it, you must get as many facts about the accident as you can by getting statements from witnesses and by interviewing the injured. The accident reporting form has spaces for information such as the people involved, the place where the accident occurred, and the date that it happened. You will also have to describe the accident, try to explain why it happened, and indicate whether it is a repeat accident. In addition, list the type of property destroyed or the type of injury. These entries are the required information only. Local reporting directives usually prescribe specific methods for notifying the ground safety officer of an accident and coordinating with security police and medical services. (*NOTE:* The procedures for making a survey and the requirements for safety meetings are also described in AFR 127–4.)

A hazard has been defined as a condition, an act, or a circumstance that jeopardizes the safety or health of Air Force personnel, the safety of a weapon system, facilities or equipment. Because of the importance of knowing the hazards, AFR 127-2, *The USAF Mishap Prevention Program*, directs that all hazards are to be reported. We are not identifying the specific form to use in making a hazard report, because forms and form numbers are often changed. Just use the form designated in the current regulation when you submit your report. Typical entries might be:

- The safety officer (name or office location).
- The person making the report.
- Location of the hazard.
- Description of the hazard.
- A recommendation for correcting the hazard.
- The date of the report and date forwarded.

These are probably the only entries for which you are responsible. Additional spaces on the form let the safety officer indicate what is done to correct the hazard and let the commander make comments and acknowledge awareness of the condition and the correction. If the reason for the accident was a missile hazard and you explained this hazard on the accident/incident form, you need not complete a USAF Hazard Report.

Exercises (227):

1. What often results when several accurate accident reports about an accident are submitted to the Air Force safety officer?

2. List five types of information required on accident reporting forms.

3. How would you report a "fender bender" involving your truck?

4. Name similar information used on accident/incident report and hazard report forms.
5. How does the Air Force increase the safety of its equipment and personnel?

4-2. Inspecting Tools, Equipment, and General Housekeeping

Many people believe that tools are simple to use and that anyone can use them with little or no training, This idea is false. Accidents are prevented when the user has had proper instruction and adequate training in caring for and in using tools safely. Although the first factor of handtool safety requires that tools be of good quality and adequate for the job at hand, this requirement is usually the responsibility of the procurement section. A place for everything and everything in its place. This maxim isn't just an old cliche; it's also a good motto for today, particularly in a shop environment.

228. State what to look for in inspecting your tools for safety.

Since there are many tools you'll use at your job and each has specific conditions that apply to it, we are limiting our information to a few common tools only. Of course, there are some conditions (such as cleanliness and good repair) pertain to all tools. Inspect your tools before you put them on the truck and leave the workcenter. Check again at the end of the work day to see that they are in good repair and are stored properly. Further, be sure that you have only the authorized tools in your kit (bag).

Inspect screwdrivers to see that the handles are clean and that the blades are not dented or bent. If you damage a blade; immediately dress it so that the bottom is flat and the sides are almost parallel. In addition, look at the screwdriver handle to ensure that it is not loose nor broken. Inspect pliers for excessive wear or for small breaks in the metal. Also, look at the jaw hinge for rust, excessive play, or binding. Both play and binding may aggravate the user and delay the work. Inspect for broken and dull teeth, warped blade, and loose or missing handle screws. On wrenches, look for a distorted or cracked jaw and a bent or mutilated handle. Inspect adjustable wrenches for binding and dirt. Inspect power tools for frayed cords, a reliable ground prong, broken or defective ON-OFF switch, and for other worn parts.

Care of climbing equipment is described in detail in the subsequent volume, but we shall briefly mention things to look for here also. Inspect the leather of the body belt and safety straps for cracks, cuts, broken thread, loose rivets, and binding snaphook keepers. Check the metal of the climbers for rust, or loose, dull, and misshapen gaffs.

Exercises (228):

1. Indicate one general condition to look for with all tools.

2. Tell the common defect to look for on a screwdriver blade.

3. State the similar fault to look for on pliers and adjustable wrenches.

4. Identify two unsafe conditions to look for on electrical tools.

5. List three conditions to look for on climbing equipment.

229. Name two test equipment components to inspect and a typical condition to look for with each.

An organization is only authorized to do limited maintenance on the test equipment. A workcenter supervisor must see that precision measuring equipment (PME) is checked, calibrated, and certified at scheduled intervals to keep it accurate and reliable. The maximum calibration interval is 6 months when an interval is not prescribed by a technical order. The occasion may arise where a supervisor decides that the local equipment laboratory service is not adequate. The supervisor then advises the laboratory of the situation and requests certification at another DOD activity.

In caring for PME, always observe the inspection schedule and allow the equipment to be used only during the safe-use period. Be sure that any PME is always handled as a "delicate instrument." See that all covers are replaced after the equipment is used and that cords, cables, accessories, etc., are properly handled and stored. Ensure that all precision measurement equipment is stored on shelves or racks. PME must be protected from shock, vibration, and the elements during transportation. Hence, some type of padding should be on the vehicle floor, and the equipment should not be stacked. Have the user clean the exterior of the equipment regularly. Inspect test equipment for damaged meters, frayed, broken, or missing leads; low-voltage battery; and loose or broken controls. Return the tools, kits, and test equipment to their proper storage position. Battery replacement and test lead repair are acceptable limited maintenance actions for some test equipment.

Exercises (229):

1. Name the power supply for most portable multimeters.

2. Identify the test equipment unit that registers the circuit condition.

3. What defect is usually found on the component of question 1?

4. Give two probable defects on the unit of question 2.

230. Identify safety hazards due to poor or improper housekeeping, and state housekeeping safety precaution(s).

Housekeeping. You would think that at our age, (over 18, that is), habit alone, would make us keep our work environment neat and clean. Do you? Take a look around your exchange the next time you have a spare minute. Are all the tools either in use or in their proper places? How about the test equipment? Are the dust covers on the equipment properly? If not, is it because someone is working on the equipment? If a dust cover is off, is it in the aisle where it can be damaged, or is it stored properly? Let's look further. Are rags, cleaning solvents, lubricants or miscellaneous hardware laying about on or under the workbench? What does the floor look like? In your workcenter, did you have to step over or around trash, tools, test equipment, or TOs that should not have been there? Were there any slick spots on the floor caused by some spilled liquid, such as oil, coffee, or coke? We have only scratched the surface, but by now you probably have a good idea of what we are talking about.

Tools, tech orders, and test equipment have no business on ladders or in the aisles once the work has stopped. Also, they should not be left lying on a bench once the job is done. If you put your equipment away when you are through working, you not only eliminate a possible accident, but also know where to find the equipment the next time you need it. Dust covers cut down on equipment problems due to dust and dirt in the air, but if you've ever stumbled over one, you probably had a few choice words for it and the person who left it there. Putting things in their proper places is essential to a safe shop.

The disposal of oily or dirty rags and the storage of flammable liquids is of considerable concern to all of us. Fire destroys millions of dollars worth of buildings and equipment each year, and it also claims thousands of lives. Simple measures, such as storing flammable liquids in an outside storage area and putting rags in a can with a self-closing lid, reduce the chance of fire. Trash on the floor and slick spots due to spilled coffee, water, wax, etc., in combination with a person in a hurry, form a potential broken back, arm, or worse. Small scraps of wire in and around the telephone equipment are probably the biggest source of central office trash on the floor. Housekeeping is important to you and the people you work with. It makes your exchange a safer place, and it makes your job easier, because no major cleanup is ever necessary.

Exercises (230):

1. Having stripped the wire and run the necessary jumpers, you immediately make the necessary connections to the 44A connecting blocks. What housekeeping hazards have you probably just created?

2. State two good housekeeping precautions to use in a workcenter.

CHAPTER 5

Technical Orders

AN AIR FORCE publication is any regulation, manual, pamphlet, memorandum, bulletin, circular, order, periodical, brochure, table, form, index catalog, list, chart, report, graphic training aid, poster, or other like printed material issued for use by appropriate personnel. Such a listing serves only to show the variety of Air Force publications. Obviously no reference library, can hold such a mountain of paper. If you know how to use indexes to find a few pertinent Air Force publications and you know how to use these publications you will be ready for the responsibilities of this career field. Your performance depends less on your ability to memorize data than on your ability to find the right information quickly.

Since your job is complex, you cannot remember all of the details of it. Your duties include using material from volumes that are authoritative sources of information and guidance. AFR 8–2, *Air Force Technical Order (TO) System*, indicates that the technical order system is the official source of all technical information. TOs may be instructions for installing, operating, maintaining, or modifying equipment. They may be lists of materials or safety procedures. The TO is broad in scope, but it does not include experimental equipment, real property, USAF stocklist publications that are specified in AFR 72–8, *The Management and Use of Federal Catalog System Publications*, or subjects suitable for issuance as standard publications (AFR 5-1, *Air Force Publications Management Program)*. This chapter will review types of TOs and procedures for locating, using, correcting and filing them.

5-1. Types of Technical Orders

Some of the types of technical orders are technical manuals (TMs), methods and procedures (MPTO), time compliance (TCTO), index type, and abbreviated-type. We shall limit our discussion to those that you will work with most.

231. Identify types of Air Force technical orders and state which TD digit having a specified meaning.

Technical Manuals. Technical Orders 00–5–1, *Technical Order System*, and 00–5–2, *Technical Order Distribution*, govern TMs, just as they do all TOs. TMs contain detailed information and instructions on equipment installation procedures, operating methods, repair procedures, etc. One or more digits of the TO number identify the type of information. To illustrate: the 1 in the second position of the technical order numbered 31W1–1–211 identifies the contents of this technical order as equipment operation information. This digit may identify both the kind of technical information in the manual and the individual technical order. In like manner, the 2 in the second position of the number 31P5–2–182 identifies the contents of the technical order as organizational maintenance information. The final digits in the number specify the applicable section of the organizational maintenance technical order. You should recognize, then, that this technical order has more than one section.

Methods and Procedures Technical Orders. MPTOs prescribe safe methods and procedures for preventive maintenance and periodic inspections. They are not related to specific equip ment as are the technical manuals.

Time Compliance Technical Orders (TCTO). The title should give you a good idea of the use of this kind of TO. There are several subtypes of TCTOs, depending on the urgency of the work.

Index TOs. Index TOs are lists that show the availability of technical orders. They also provide a cross-reference to other publications, when necessary. Any technical order can be located when you know how to use index TOs. If you don't know how to locate the information you need, you have limited value to your organization. The TO system is of little value if you don't know how to use it. Another section in this chapter tells you how to locate a TO in a limited file.

Abbreviated Technical Orders. You will use preventive maintenance workcards, which are in this category. They are work simplification devices. Technical orders of this type have a regular number, to which a WC is added.

Exercises (231):

1. Name the authoritative sources of information about TOs.

2. What digit in a TO number denotes that the information in the TO is organizational maintenance?

3. Which TOs identify other TOs in the organizational file?

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4. You have been given to 31P–2–176WC–1. What kind of TO is it?

5. You need the operation and maintenance instructions for the 1A1 key system. How do you find them?

232. Locate specified information on typical technical order index pages (figs. 5-1 through 5-4).

Locating Technical Orders Two indexes that you may use to locate technical order information are the numerical index (0–1 series) and the alphabetical index (0–2–1).

You will usually use the numerical index and requirements table, NI&RT, to locate TO numbers.

Numerical Index. In most cases, you'll know the index you need to use; but this is not always true. If you had to find a TO for troubleshooting the 302 communications equipment for instance, you would need an index that serves Ground Radar Electronic Equipment. The best place to identify the index you need is TO 0–1–01, the numerical index of technical order indexes. Figure 5-1 is a page from this index. By examining the titles of the indexes of the sample page, you can see that the Ground Radar Electronic Equipment technical orders are in the 0–1–31–3 index.

You can see infigure 5-2 that TO 0-1-31-3, lists several technical orders for the 302 Switching Unit. The first page of the index that lists such technical orders is page 1-81. Figure 5-2 shows page 1-82 of this index. Let's look at a publications number and the title on this page. To illustrate: 31P5-2-182 is one publication listed on this page. Its title is *SVC INSTR—302 Switching Unit for Radar Set, Type AN/CPN–4 and LDG Control set, Type AN/MPN–11*. Note, also, the date of this publication at the right of the page and the most recent change. Compare this date with the publication date of the title page. Also, compare the title page date of the index to the date listed in the "Index of Indexes" to ensure that this is the most recently published TO 0–1–31–3.

A specific type of equipment is often listed as a major heading. Then, thereafter, the related technical orders are listed underneath it. Take, for example, the TO just referred to, TO 0–1–31–3. Here TYPE AN/CPN EQUIPMENT—GENERAL is given as a major heading. Under it, you will find operating instruction manuals, checklists, and supplements given.

You search through the numerical index and requirement table (NI&RT) for your equipment until you find the publication you want. There may be letters and digits that may not be familiar. For example, to the left of 31P5–2FPN16 you can see an S. This symbol indicates that it is one of a series. The meaning of this letter and the other symbols can be found in TO 0–1–01. Write down the technical order number for your manual and then look at the labels on the technical order binders in the file and locate the right binder.

The publications listed in the 31 group are not the complete listing for which you will be responsible. You are aware that you also work with test equipment. Thus, there must be technical orders for each type of test set. The NI&RT that pertains to test equipment is TO 0–1–33–1. Let us spend a few minutes in locating a sample test unit. Assume that you want to study the preoperating and operating procedures for the AN/PSM–6 series multimeter. You take TO 0–1–33–1, *General Purpose Test and Associated Equipment Technical Orders*, from the file and scan the table of contents. Figure 5-3 shows this page. Since mulimeters test voltage, current, and resistance, you look for this heading. We are showing an arrow pointing to the number for this category of equipment. Write down this number (33A1–12) and the page number (189). Now, turn the pages until you arrive at the recorded number. Continue turning pages and looking for equipment titles until you find Type AN/PSM–6 Series. To the left of this title, you will see the specific technical order number for this test set. It is –2; thus, the entire technical order number for the operating manual is TO 33A–1–12–2–1. Return the NI&RT to the file. If the file contains a binder with TO 33A1–12–2–1, get it. Section 1 of this technical order provides the preoperating and operating procedures for the AN/PSM–6 multimeter.

Alphabetical Index. To learn the technical publications number group for your equipment, you can also use the alphabetical index (0–2–1). Thumbing through the pages of this index, you will find equipment listed. Turn the pages until you find Ground Radar Electronic Equipment Technical Orders. Opposite this title you will see 0–1–31–3.

Since most manufacturers furnish the technical information that covers their product, it is evident that a file may include a publication that provides this type of information. Your base library has a commerical publications file for technical books and magazines. In addition, AFM 67–1, *USAF Supply Manual*, prescribes the procedures for procuring and storing commercial publications that have no Air Force number. If a commercial publications is given an Air Force number, it will be listed in the NI&RT. and filed according to the directives we have previously mentioned.

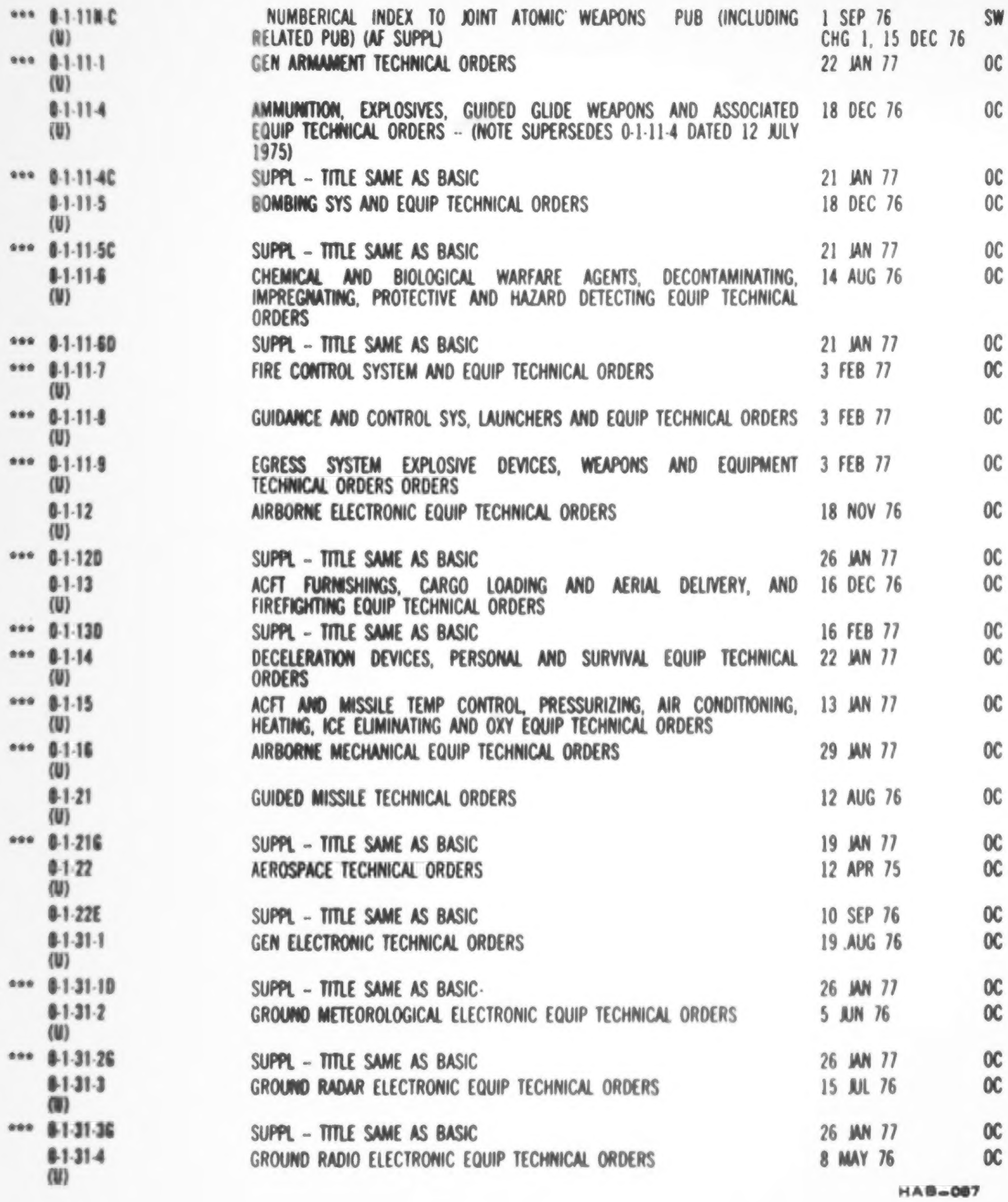
Exercises (232):

1. You have been asked to get and use the index airmen involved in operating survival equipment employ. Identify this index, using figure 5-1 as necessary.

2. Give the first part of the number for the guided missile technical orders.

3. What is the title of TO 31P5–2–183?

4. TO 31P5–2–186WC–1 contains specific information. State the type of such information found here.



***	0-1-11N-C (U)	NUMBERICAL INDEX TO JOINT ATOMIC WEAPONS PUB (INCLUDING RELATED PUB) (AF SUPPL)	1 SEP 76 CHG 1, 15 DEC 76	SW
***	0-1-11-1 (U)	GEN ARMAMENT TECHNICAL ORDERS	22 JAN 77	OC
	0-1-11-4 (U)	AMMUNITION, EXPLOSIVES, GUIDED GLIDE WEAPONS AND ASSOCIATED EQUIP TECHNICAL ORDERS -- (NOTE SUPERSEDES 0-1-11-4 DATED 12 JULY 1975)	18 DEC 76	OC
***	0-1-11-4C	SUPPL - TITLE SAME AS BASIC	21 JAN 77	OC
	0-1-11-5 (U)	BOMBING SYS AND EQUIP TECHNICAL ORDERS	18 DEC 76	OC
***	0-1-11-5C	SUPPL - TITLE SAME AS BASIC	21 JAN 77	OC
	0-1-11-6 (U)	CHEMICAL AND BIOLOGICAL WARFARE AGENTS, DECONTAMINATING, IMPREGNATING, PROTECTIVE AND HAZARD DETECTING EQUIP TECHNICAL ORDERS	14 AUG 76	OC
***	0-1-11-6D	SUPPL - TITLE SAME AS BASIC	21 JAN 77	OC
***	0-1-11-7 (U)	FIRE CONTROL SYSTEM AND EQUIP TECHNICAL ORDERS	3 FEB 77	OC
***	0-1-11-8 (U)	GUIDANCE AND CONTROL SYS, LAUNCHERS AND EQUIP TECHNICAL ORDERS	3 FEB 77	OC
***	0-1-11-9 (U)	EGRESS SYSTEM EXPLOSIVE DEVICES, WEAPONS AND EQUIPMENT TECHNICAL ORDERS ORDERS	3 FEB 77	OC
	0-1-12 (U)	AIRBORNE ELECTRONIC EQUIP TECHNICAL ORDERS	18 NOV 76	OC
***	0-1-12D	SUPPL - TITLE SAME AS BASIC	26 JAN 77	OC
	0-1-13 (U)	ACFT FURNISHINGS, CARGO LOADING AND AERIAL DELIVERY, AND FIREFIGHTING EQUIP TECHNICAL ORDERS	16 DEC 76	OC
***	0-1-13D	SUPPL - TITLE SAME AS BASIC	16 FEB 77	OC
***	0-1-14 (U)	DECELERATION DEVICES, PERSONAL AND SURVIVAL EQUIP TECHNICAL ORDERS	22 JAN 77	OC
***	0-1-15 (U)	ACFT AND MISSILE TEMP CONTROL, PRESSURIZING, AIR CONDITIONING, HEATING, ICE ELIMINATING AND OXY EQUIP TECHNICAL ORDERS	13 JAN 77	OC
***	0-1-16 (U)	AIRBORNE MECHANICAL EQUIP TECHNICAL ORDERS	29 JAN 77	OC
	0-1-21 (U)	GUIDED MISSILE TECHNICAL ORDERS	12 AUG 76	OC
***	0-1-21G	SUPPL - TITLE SAME AS BASIC	19 JAN 77	OC
	0-1-22 (U)	AEROSPACE TECHNICAL ORDERS	12 APR 75	OC
	0-1-22E	SUPPL - TITLE SAME AS BASIC	10 SEP 76	OC
	0-1-31-1 (U)	GEN ELECTRONIC TECHNICAL ORDERS	19 AUG 76	OC
***	0-1-31-1D	SUPPL - TITLE SAME AS BASIC	26 JAN 77	OC
	0-1-31-2 (U)	GROUND METEOROLOGICAL ELECTRONIC EQUIP TECHNICAL ORDERS	5 JUN 76	OC
***	0-1-31-2G	SUPPL - TITLE SAME AS BASIC	26 JAN 77	OC
	0-1-31-3 (U)	GROUND RADAR ELECTRONIC EQUIP TECHNICAL ORDERS	15 JUL 76	OC
***	0-1-31-3G	SUPPL - TITLE SAME AS BASIC	26 JAN 77	OC
	0-1-31-4 (U)	GROUND RADIO ELECTRONIC EQUIP TECHNICAL ORDERS	8 MAY 76	OC

HAB-087

Figure 5-1. Sample page from TO 0-1-01.

31P5-2-172S-1	OPR SUPPL -- TITLE SAME AS BASIC	1 MAY 74	SM
31P5-2-173 (U)	CIRCUIT DIAGRAMS -- 302 SWITCHING UNIT FOR MOBILE RAPCON (WESTERN ELECTRIC)	31 JAN 62 CHG 6, 1 SEP 76	SM
31P5-2-176WC-1 (U)	PREVENTIVE MAINT WORKCARD SET -- 302 SWITCHING UNIT, FOR MOBILE RADAR APPROACH CONTROL CENTER (WESTERN ELECTRIC)	15 FEB 62 CHG 5, 12 OCT 78	SM
31P5-2-182 (U)	SVC INSTR -- 302 SWITCHING UNIT FOR RADAR SET, TYPE AN/CPN-4() AND LDG CONTROL SET, TYPE AN/MPN-11() (WESTERN ELECTRIC)	31 JAN 62 CHG 9, 19 AUG 77	SM
31P5-2-183 (U)	CIRCUIT DIAGRAMS -- 302 SWITCHING UNIT, RADAR SET, TYPE AN/CPN-4() AND LDG CONTROL SET, TYPE AN/MPN-11() (WESTERN ELECTRIC)	31 JAN 62 CHG 6, 1 OCT 73	SM
31P5-2-183C	SUPPL -- TITLE SAME AS BASIC	8 JUN 77	SM
31P5-2-183D	SUPPL -- TITLE SAME AS BASIC	14 OCT 77	SM
31P5-2-184 (U)	IPB -- 302 SWITCHING UNIT FOR RADAR SET, TYPE AN/CPN-4, AND LDG CONTROL SET, TYPE AN/MPN-11, MOBILE RAPCON, AND FIXED RAPCON (WESTERN ELECTRIC)	31 MAY 62 CHG 8, 1 MAY 75	SM
31P5-2-184C	SUPPL -- TITLE SAME AS BASIC	13 JAN 78	SM
31P5-2-186WC-1 (U)	PREVENTIVE MAINT WORKCARD SET -- 302 SWITCHING UNIT, FOR RADAR SET, TYPE AN/CPN-4(), LDG CONTROL SET, TYPE AN/MPN-11() (WESTERN ELECTRIC)	15 FEB 62 CHG 5, 8 JUN 77	SM
. 31P5-2-566	INSP TO INSURE STANDARDIZATION OF WIRING IN INDICATOR DUCTS FOR PROPER AC POWER INPUT SOURCE TO TPX-49 IN LANDING CONTROL CENTRALS AN/MPN-13() AND AN/MPN-14() AN/MPN13(),AN/MPN14(),AN/TPX42 (RESC DATE 5 JUN 79)	5 JUN 78	SM
	TYPE AN/CPN EQUIPMENT--GENERAL		
	TYPE AN/CPN-2 SERIES		
31P5-2CPN2-42 (U)	SVC INSTR -- RADIO SET, TYPE AN/CPN-2A (RADIO CORPORATION OF AMERICA) -- TRAFFIC CONTROL APPROACH AND LDG SYS	7 FEB 55 CHG, 15 MAR 70	SM
	TYPE AN/CPN-6		
31P5-2CPN6-1 (U)	OPR AND SVC INSTR -- RADIO SET, TYPE AN/CPN-6 (GALVIN) -- TRAFFIC CONTROL APPROACH AND LDG SYS	1 OCT 52	SM
31P5-2CPN6-2 (U)	MAINT INSTR -- RADIO SET, TYPE AN/CPN-6 (GALVIN) -- TRAFFIC CONTROL APPROACH AND LDG SYS	4 JUL 45 CHG, 15 DEC 52	SM
31P5-2CPN6-14 (U)	SPARE P/L -- RADIO SET, TYPE AN/CPN-6 -- TRAFFIC CONTROL APPROACH AND LDG SYS	15 JAN 57	SM
31P5-2CPN6-24 (U)	IPB -- RADIO SET, TYPE AN/CPN-6 -- TRAFFIC CONTROL APPROACH AND LDG SYS	1 MAY 59	SM
	TYPE AN/FPN EQUIPMENT--GENERAL		
	TYPE AN/FPN-16		
S 31P5-2FPN16 (U)	TCTO SERIES		
31P5-2FPN16-2 (U)	SVC INSTR -- RADAR SET, TYPE AN/FPN-16() (ITT GILFILLAN) -- TRAFFIC CONTROL AND APPROACH SYS	1 SEP 72 CHG 9, 28 APR 78	SM
31P5-2FPN16-2D	SUPPL -- TITLE SAME AS BASIC	1 FEB 79	SM
31P5-2FPN16-2SS-1	SAFETY SUPPL -- TITLE SAME AS BASIC	11 JUL 78	SM
31P5-2FPN16-2-3 (U)	SUPPLEMENTARY MANUAL -- SVC INSTR -- RADAR SET, TYPE AN/FPN-16 (INTERNATIONAL TELEPHONE AND TELEGRAPH GILFILLAN) -- AN/FPN16*TRAFFIC CONTROL APPROACH LDG SYS	1 DEC 69	SM
31P5-2FPN16-3 (U)	CIRCUIT DIAGRAMS -- RADAR SET, TYPE AN/FPN-16 (ITT GILFILLAN) -- TRAFFIC CONTROL APPROACH AND LDG SYS	15 DEC 60 CHG 26, 13 FEB 78	SM

Figure 5–2. Sample page of NI&RT, TO 0–1–33–1.

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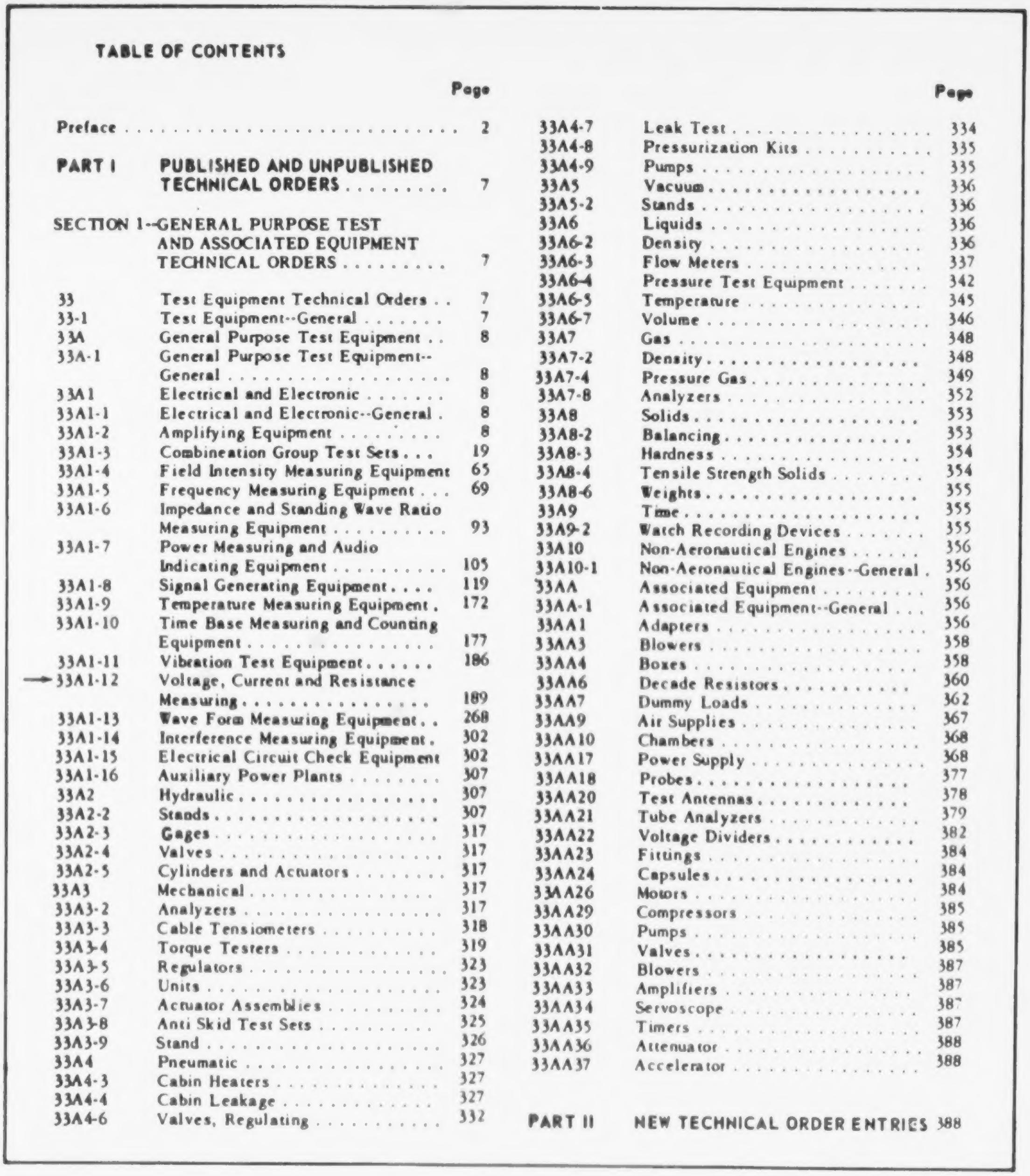
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Figure 5–3. Table of Contents page for TO 0–1–33–1.

5. A specific TO contains information you need about the test set used for applying current to relays. Relate the initial number of this TO.

233. Use TO tables of contents to locate information within the TO.

Using Technical Orders. Having noted that TO 31P5–2–182 is in the file and located it, we shall mention one way in which it has been used. Figure 5-4 is a table of contents page for TO 31P5–2–182. Looking at it, you can see three chapters listed. Chapter 2 is titled "INSTALLATION," and it has four sections: Introduction, Installation Planning, Logistics, Installation Procedures, and Preparation for Reshipment. Assuming that you want information about adjustment and testing the 106B loudspeaker, look in Section III (page 2-28). Figure 5-5 shows that the 106B information is now on page 2-27, following change 5. On this page we find that you adjust the speaker by removing the cover and rotating the chassis gain control.

Exercises (233):

1. List the logistics information in Chapter 2 of TO 31P5–2–182.

2. What chapter and section has information about the operation of the wire-line and radio controls and indicators?

3. What page has information about the installation of the external cables?

234. State how to report TO deficiencies.

Reporting Technical Drder Deficiencies. Not every task or procedure can be adequately covered. Perhaps through experience you will think of a better way of doing the job. During the development of the publication a schematic or an instruction may have had an important unit or step omitted. You are obligated to report this type of technical deficiency. TO 00–5–1 presents the procedures for correcting such technical deficiencies. The device to use is the AFTO Form 22, Technical Order System Publication Improvement Report and Reply.

You should recognize that errors in a technical order could vary in importance. For instance, a misspelled word is sometimes a minor deficiency, whereas an incorrect drawing or an omitted procedure would more likely be a significant technical deficiency. Therefore, you should consider the importance of each error you see. Minor errors should not be reported. Technical errors have different priorities: emergency, urgent, and routine.

The words "emergency," "urgent," and "routine" should be meaningful to you. Emergency always implies immediate action is required. This is because an unsafe condition exists that would result in serious injury or in damage to equipment. Likewise, urgent implies a hazardous condition, but it is less important than the emergency condition. Technical order changes for missile communications are usually considered routine. When you need to submit an improvement report, look in TO 00–5–1 for a detailed explanation of these three priorities.

Complete the report form with the specific information that identifies the suspected error. *NOTE:* Only one deficiency is authorized per form. For example, provide the technical order number in the block designated as TO No. Include the page and paragraph number in the proper blocks. Of course, if a schematic is incorrect, write the figure number in the identified block. Further, you must also show the date of the defective TO. In the summarizing block of the form, describe the deficiency and follow the description with a recommended change.

An emergency report should be followed up by the originating organization after 60 hours, an urgent report should be followed up after 45 days, and a routine report should be followed up after 90 days. The followup request is submitted through the same channels as the original report used.

Exercises (234):

1. What AFTO form has a block titled "Brief Summary of Technical Order Deficiency and Recommend Change"?

2. What are the priorities for reporting technical order deficiencies?

3. Cite four bits of information that must go on the TO improvement form?

5-2. Standard Publications

These publications are used to announce policies, assign responsibilities, prescribe procedures, issue training instructions, and provide information they include Air Force regulations (AFRs), manuals (AFMs), pamphlets (AFPs) and Supplements.

235. State what kind of information is found in standard publications.

Regulations. Regulations are permanent, except when it is known that the need for one is limited to a certain period. In

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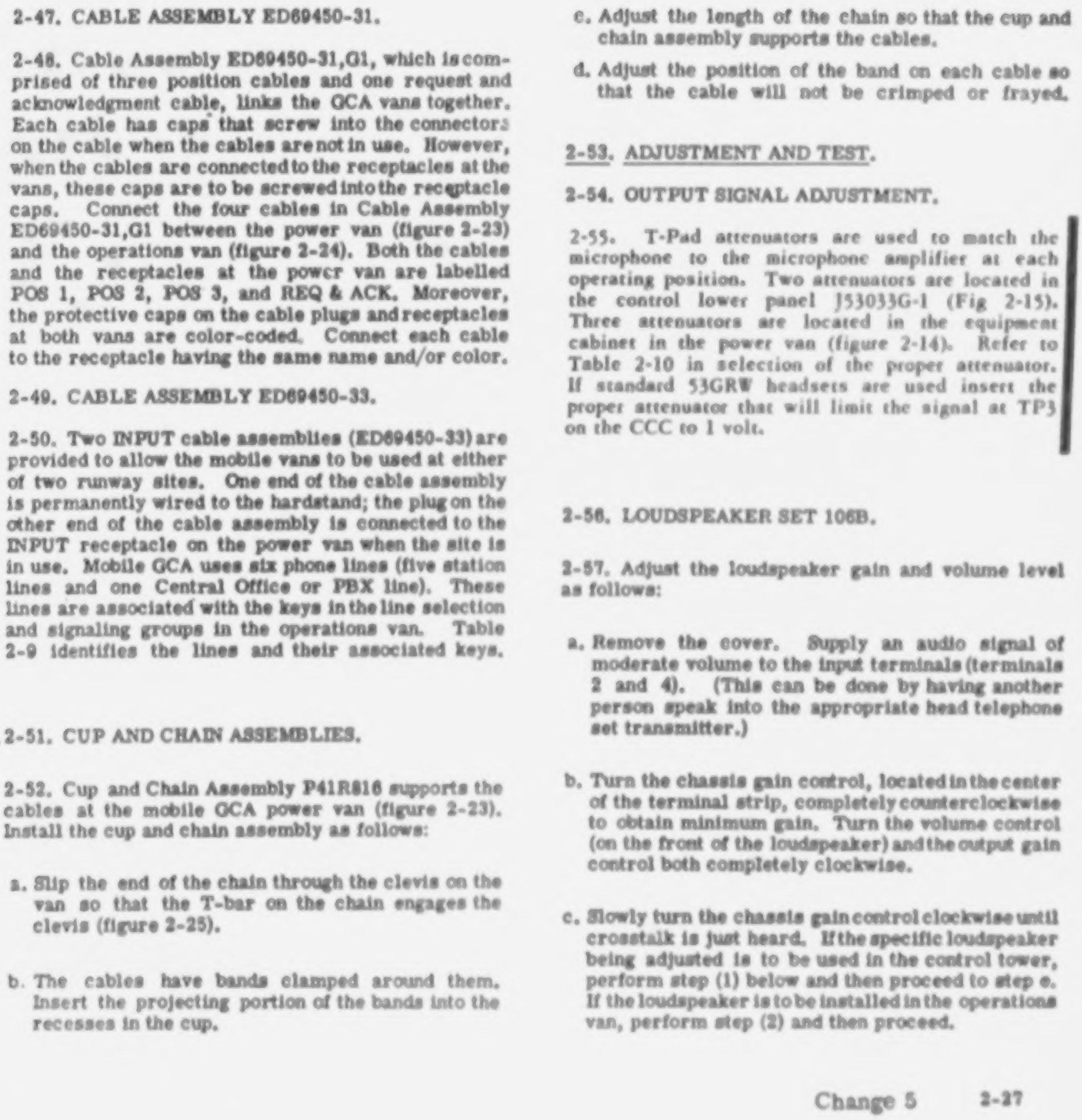
Figure 5-4. Table of Contents page for TO 31P5-2-182.



2-47. CABLE ASSEMBLY ED69450-31.

2-48. Cable Assembly ED69450-31,G1, which is comprised of three position cables and one request and acknowledgment cable, links the GCA vans together. Each cable has caps that screw into the connectors on the cable when the cables are not in use. However, when the cables are connected to the receptacles at the vans, these caps are to be screwed into the receptacle caps. Connect the four cables in Cable Assembly ED69450-31,G1 between the power van (figure 2-23) and the operations van (figure 2-24). Both the cables and the receptacles at the power van are labelled POS 1, POS 2, POS 3, and REQ & ACK. Moreover, the protective caps on the cable plugs and receptacles at both vans are color-coded. Connect each cable to the receptacle having the same name and/or color.

2-49. CABLE ASSEMBLY ED69450-33.

2-50. Two INPUT cable assemblies (ED69450-33) are provided to allow the mobile vans to be used at either of two runway sites. One end of the cable assembly is permanently wired to the hardstand; the plug on the other end of the cable assembly is connected to the INPUT receptacle on the power van when the site is in use. Mobile GCA uses six phone lines (five station lines and one Central Office or PBX line). These lines are associated with the keys in the line selection and signaling groups in the operations van. Table 2-9 identifies the lines and their associated keys.

2-51. CUP AND CHAIN ASSEMBLIES.

2-52. Cup and Chain Assembly P41R816 supports the cables at the mobile GCA power van (figure 2-23). Install the cup and chain assembly as follows:

a. Slip the end of the chain through the clevis on the van so that the T-bar on the chain engages the clevis (figure 2-25).

b. The cables have bands clamped around them. Insert the projecting portion of the bands into the recesses in the cup.

c. Adjust the length of the chain so that the cup and chain assembly supports the cables.

d. Adjust the position of the band on each cable so that the cable will not be crimped or frayed.

2-53. ADJUSTMENT AND TEST.

2-54. OUTPUT SIGNAL ADJUSTMENT.

2-55. T-Pad attenuators are used to match the microphone to the microphone amplifier at each operating position. Two attenuators are located in the control lower panel J53033G-1 (Fig 2-15). Three attenuators are located in the equipment cabinet in the power van (figure 2-14). Refer to Table 2-10 in selection of the proper attenuator. If standard 53GRW headsets are used insert the proper attenuator that will limit the signal at TP3 on the CCC to 1 volt.

2-56. LOUDSPEAKER SET 106B.

2-57. Adjust the loudspeaker gain and volume level as follows:

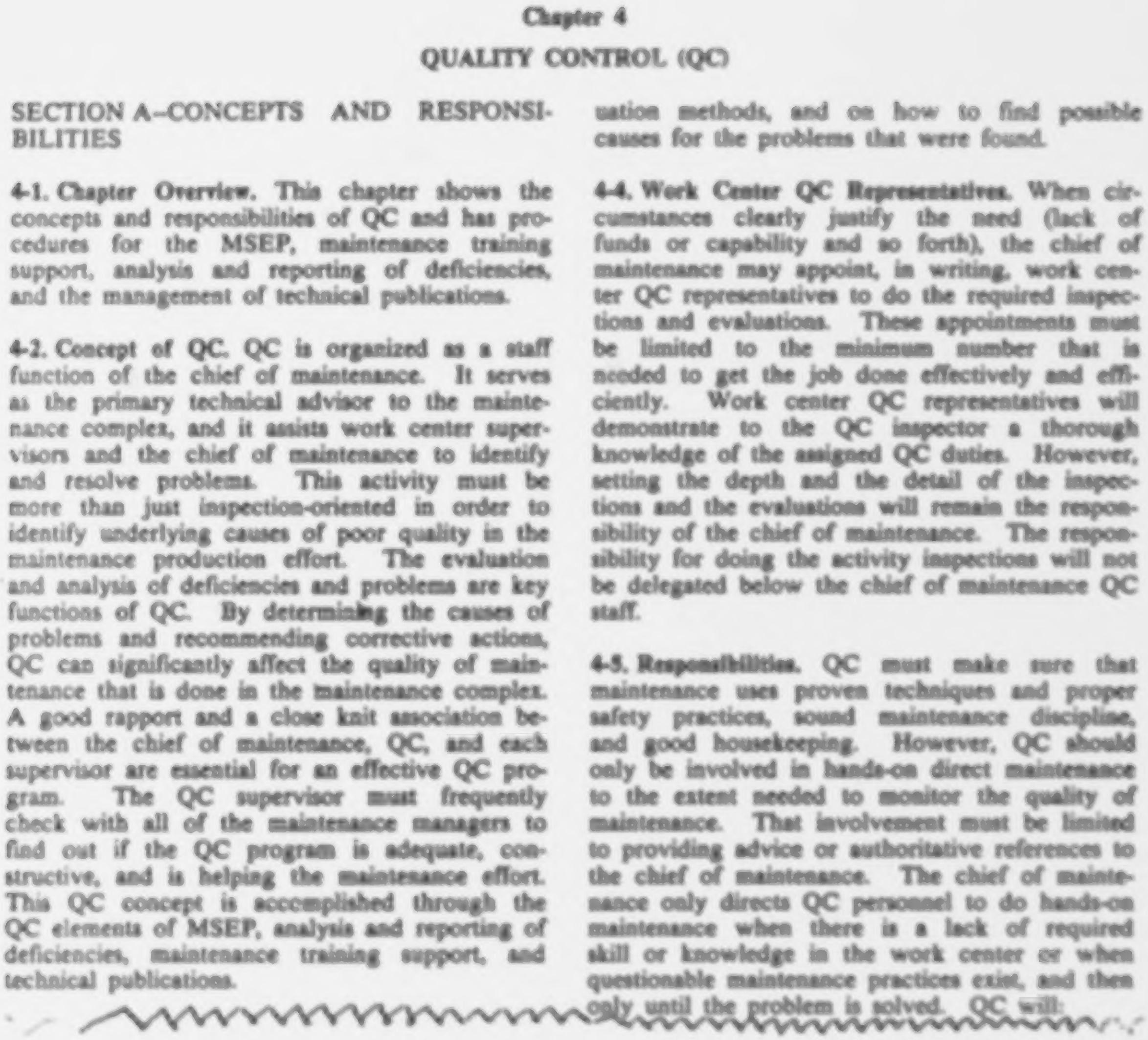
a. Remove the cover. Supply an audio signal of moderate volume to the input terminals (terminals 2 and 4). (This can be done by having another person speak into the appropriate head telephone set transmitter.)

b. Turn the chassis gain control, located in the center of the terminal strip, completely counterclockwise to obtain minimum gain. Turn the volume control (on the front of the loudspeaker) and the output gain control both completely clockwise.

c. Slowly turn the chassis gain control clockwise until crosstalk is just heard. If the specific loudspeaker being adjusted is to be used in the control tower, perform step (1) below and then proceed to step e. If the loudspeaker is to be installed in the operations van, perform step (2) and then proceed.

Change 5 2-27

Figure 5-5. Sample page of TO 31P5-2-182.



Chapter 4

QUALITY CONTROL (QC)

SECTION A–CONCEPTS AND RESPONSIBILITIES

4-1. Chapter Overview. This chapter shows the concepts and responsibilities of QC and has procedures for the MSEP, maintenance training support, analysis and reporting of deficiencies, and the management of technical publications.

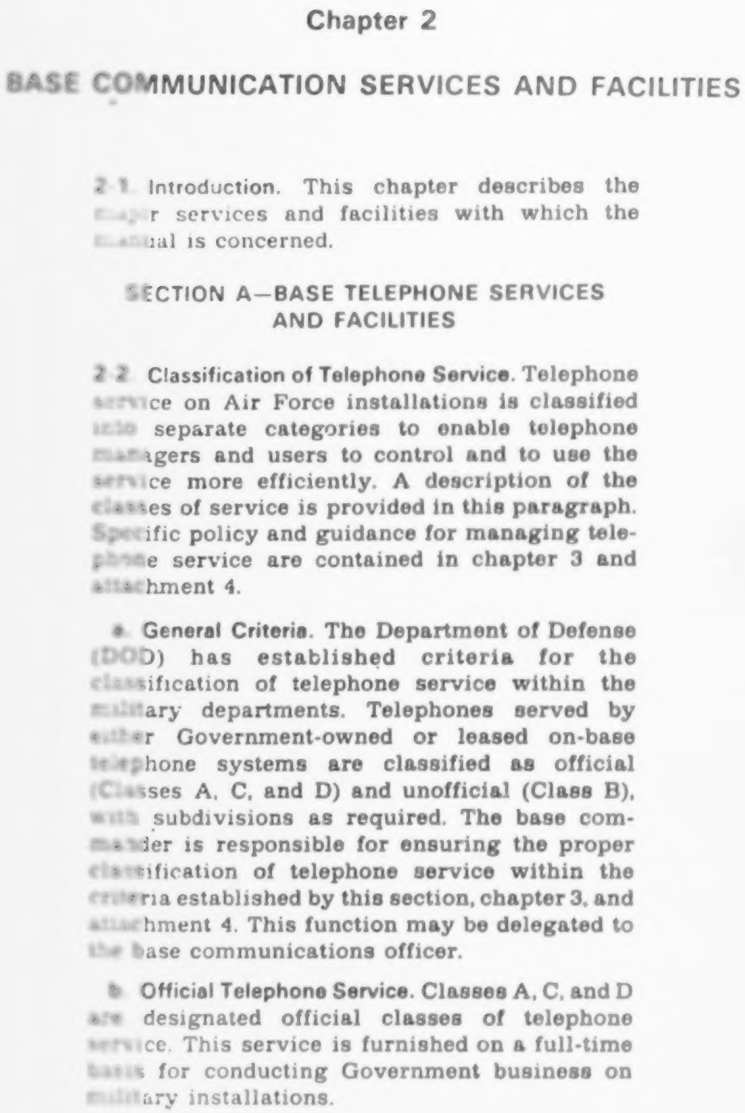
4-2. Concept of QC. QC is organized as a staff function of the chief of maintenance. It serves as the primary technical advisor to the maintenance complex, and it assists work center supervisors and the chief of maintenance to identify and resolve problems. This activity must be more than just inspection-oriented in order to identify underlying causes of poor quality in the maintenance production effort. The evaluation and analysis of deficiencies and problems are key functions of QC. By determining the causes of problems and recommending corrective actions, QC can significantly affect the quality of maintenance that is done in the maintenance complex. A good rapport and a close knit association between the chief of maintenance, QC, and each supervisor are essential for an effective QC program. The QC supervisor must frequently check with all of the maintenance managers to find out if the QC program is adequate, constructive, and is helping the maintenance effort. This QC concept is accomplished through the QC elements of MSEP, analysis and reporting of deficiencies, maintenance training support, and technical publications.

uation methods, and on how to find possible causes for the problems that were found.

4-4. Work Center QC Representatives. When circumstances clearly justify the need (lack of funds or capability and so forth), the chief of maintenance may appoint, in writing, work center QC representatives to do the required inspections and evaluations. These appointments must be limited to the minimum number that is needed to get the job done effectively and efficiently. Work center QC representatives will demonstrate to the QC inspector a thorough knowledge of the assigned QC duties. However, setting the depth and the detail of the inspections and the evaluations will remain the responsibility of the chief of maintenance. The responsibility for doing the activity inspections will not be delegated below the chief of maintenance QC staff.

4-5. Responsibilities. QC must make sure that maintenance uses proven techniques and proper safety practices, sound maintenance discipline, and good housekeeping. However, QC should only be involved in hands-on direct maintenance to the extent needed to monitor the quality of maintenance. That involvement must be limited to providing advice or authoritative references to the chief of maintenance. The chief of maintenance only directs QC personnel to do hands-on maintenance when there is a lack of required skill or knowledge in the work center or when questionable maintenance practices exist, and then only until the problem is solved. QC will:

Figure 5-6. Partial page from AFR 66-1, Volume 5.



Chapter 2

BASE COMMUNICATION SERVICES AND FACILITIES

2-1. Introduction. This chapter describes the major services and facilities with which the manual is concerned.

SECTION A—BASE TELEPHONE SERVICES AND FACILITIES

2-2. **Classification of Telephone Service.** Telephone service on Air Force installations is classified into separate categories to enable telephone managers and users to control and to use the service more efficiently. A description of the classes of service is provided in this paragraph. Specific policy and guidance for managing telephone service are contained in chapter 3 and attachment 4.

a. **General Criteria.** The Department of Defense (DOD) has established criteria for the classification of telephone service within the military departments. Telephones served by either Government-owned or leased on-base telephone systems are classified as official (Classes A, C, and D) and unofficial (Class B), with subdivisions as required. The base commander is responsible for ensuring the proper classification of telephone service within the criteria established by this section, chapter 3, and attachment 4. This function may be delegated to the base communications officer.

b. **Official Telephone Service.** Classes A, C, and D are designated official classes of telephone service. This service is furnished on a full-time basis for conducting Government business on military installations.

Figure 5–7. Partial page from AFM 100–22.

this case, an expiration date is given. AFRs give directions and assign responsibilities. Figure 5-6 is a partial page of AFR 66–1, Volume 5. Part of Section A of Chapter 4 is illustrated. The chapter is about quality control. The paragraphs shown tell the concept of the QC unit and identify some of its responsibilities. Of course, much greater detail about the unit and its responsibilities are provided in the rest of the chapter.

Manuals. Manuals provide detailed instructions. Consequently, they usually contain more pages than an AFR. Figure 5-7 is a partial page of AFM 100–22. Section A describes base telephone services and facilities. Included is the classification of telephone service. Accordingly, official telephone systems (owned or leased) are classed as A, C, and D service. The same paragraph also states that the base commander is responsible for ensuring that the telephones are properly classified, yet she or he may delegate the responsibility to the base communications officer.

Pamphlets. Pamphlets usually consist of information that is written not to give directions but to create interest about a subject. For example, AFP 39–8 is the *Weighted Airman Promotion System (WAPS) Study Reference List*.

Supplements. A supplement adds to the guidance of a publication. usually at a lower level. However, the supplement must not alter or change the basic publication.

In the same manner as with technical orders, standard publications have numbers and titles that permit orderly filing. The file includes an index, and again, the basic number in the index is 0. AFR 0–2 is the *Numerical Index of Standard Air Force Publications*. You get the number and title of a standard publication by scanning the pages of AFR 0–2. Then you look at the binders to get the specific publication.

Success in your career field will be determined by how you do your job. The way that you do this job is guided by technical instructions. To a great extent then, your success depends on your efficient use of technical publications. Take the time to practice the suggested methods for locating technical publications in a limited file.

Exercises (235):

1. Using figure 5-6, tell three responsibilities of the quality control unit.

2. Using figure 5-7, identify the class of service for a telephone that doesn't have access to AUTOVON trunks.

3. Give the number for the numerical index of standard Air Force publications.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

200 – 1. The transmitter diaphragm moves into and out-of a cup having carbon granules, thereby changing the telephone circuit resistance and its current.
200 – 2. Diaphragm, carbon cup, and cup-to-conductor contacts.
200 – 3. It is now a thin, aluminum-alloy disc, supported by paper at the edges, with a protective silk screen to keep out moisture.
200 – 4. It is worn directly in front of the lips, so it can cancel any noise from other directions.

201 – 1. Diaphragm, permanent magnet, coil and pole pieces, terminal plate, and varistor.
201 – 2. Current in the telephone circuit conductors creates a magnetic field around the receiver coil. This magnetic field pulls the diaphragm or allows it to relax, thereby creating sound waves that match the original sound waves striking the transmitter.

202 – 1. Primary, secondary and balancing.
202 – 2. To provide good transmission and reception and to reduce and control sidetone during the transmission.
202 – 3. Capacitors block direct current, are used in ringing circuits to pass the prescribed ringing current, and aid in reducing the telephone circuit sidetone.
202 – 4. The telephone circuit ringer and the induction coil.

203 – 1. Switchboard(s), switching, connecting, and power equipment.
203 – 2. Telephone line.
203 – 3. Trunks.
203 – 4. Transmitter, receiver, ringer, hookswitch, network, dial, and connecting cords.
203 – 5. The central office battery is rechargeable and its voltage is more stable.
203 – 6. To signal from a common-battery station, the attendant needs only to lift the handset from the hookswitch.
203 – 7. The battery and the magneto generator have been removed from the telephone set.

CHAPTER 2

204 – 1. With the dial.
204 – 2. Strowger and XY systems.
204 – 3. Linefinder switch.
204 – 4. Connector switch.
204 – 5. The telephone dial opens and closes a telephone switching equipment circuit the number of times that corresponds to the dialed digit. Each circuit completion steps the switch wipers to another level to make another connection.
204 – 6. Linefinder.
204 – 7. Two.
204 – 8. Ten.
204 – 9. Line wiper and terminal bank terminal.
204 – 10. Both switches step following the dial.
204 – 11. The Strowger switch is upright whereas the XY switch lies down. Also, the Strowger switch has line bank contact terminals whereas the XY switch has wire terminals that terminate the line circuits.
204 – 12. Wipers and banks.
204 – 13. When the caller dials the first digit, the wipers are moved in the X direction. The dialed second digit then operates the XY switch in the Y direction.

205 – 1. Lifting and replacing the handset.
205 – 2. Dial pulse springs.
205 – 3. Dial shunt springs.
205 – 4. Replacement of the handset on the cradle switch connects the ringer to the line loop.
205 – 5. L1.
205 – 6. L2.

206 – 1. TTMF keyboard and tone matrix.
206 – 2. 697 and 1477 cps.
206 – 3. The tones from the TTMF are changed to pulses by an electronic equipment and these pulses then actuate the step-by-step switches as required.
206 – 4. The interface equipment converts the pulses to tones for signaling purposes and also converts the voice frequencies to specified tones for conversational purposes.

207 – 1. A relay.
207 – 2. Relay and magnets.
207 – 3. The switching equipment is restored to the normal rest position.

208 – 1. Number and finger plates and fingerstop.
208 – 2. Pulse and shunt cams.
208 – 3. Dial pulse spring contacts.
208 – 4. The shunt springs shunt the receiver and transmitter during dialing.
208 – 5. Governor assembly.
208 – 6. Pulse cam.
208 – 7. Primary winding of network induction coil and transmitter.
208 – 8. For some dials, the springs shunt the receiver and in others the springs open the receiver circuit.

209 – 1. Two conductors attach to the network and transmitter, and two conductors connect between the network and receiver.
209 – 2. Spring contacts for the handset cord mate with silver contacts for the transmitter.
209 – 3. Improves transmissions by reducing sound feedback and holds the transmitter in position.
209 – 4. Varistor.
209 – 5. Screws attach the two handset conductors to the telephone receiver.
209 – 6. B,C,D and E.
209 – 7. Closed.
209 – 8. Ringer coil, coil core, and brass gongs.
209 – 9. It must be remagnetized.
209 – 10. The spade tips for the four conductors from the contact springs are inserted under four screw terminals of the network.
209 – 11. Replace the telephone; then take it to the shop and replace the network there.

210 – 1. Ringer circuit.
210 – 2. Transmitter, receiver, antisidetone, and dialing circuits.
210 – 3. Varistors.
210 – 4. The terminals for the network.
210 – 5. RING.
210 – 6. Positive battery (ground).

211 – 1. Connect the yellow conductor at network terminal G and the connecting block TIP terminal, and connect the red conductor at terminal L2 of the network and the RING terminal of the connecting block.
211 – 2. On the cradle.
211 – 3. 85 vac at 20 cycles per second.
211 – 4. Capacitor C4.
211 – 5. Black.
211 – 6. Slate.

212 – 1. Handset is lifted.
212 – 2. C3 capacitor and CR2 varistor.
212 – 3. Series connection.
212 – 4. C2 capacitor.

213 – 1. GN, R, RR, B and C.
213 – 2. R2, C1 and C2, CR1 and C2, and C1, S1, GN, receiver, transmitter, terminal B, R1 and S2.

214 – 1. Voltage induction.
214 – 2. Voltage and current cancellation in the telephone induction coil windings.
214 – 3. S2 and CR1, and resistor R1, the transmitter, and terminals B & R.

215 – 1. TIP and RING are connected together by means of a central office relay.
215 – 2. Dial tone from the central office.
215 – 3. 12 (Six open and six closed periods.)
215 – 4. Capacitor C3 and resistor R3.

216 – 1. Wall model, key type, explosionproof, and weatherproof sets.
216 – 2. The only difference is that the wall phone has a base and housing that permits it to be mounted on a wall.
216 – 3. It is housed within cast aluminum and sealed to keep out fumes.
216 – 4. Enclosed within a housing sealed from moisture.
216 – 5. Plug in the handset (headset-transmitter assembly), lift the handset from the cradle, and make the comment or request to the telephone user at the opposite end.

CHAPTER 3

217 – 1. Organizational, intermediate, and depot levels.
217 – 2. Organizational.
217 – 3. Organizational.
217 – 4. Intermediate or depot level.
217 – 5. Most calibrations and modifications are depot-level maintenance, but some are accomplished at the intermediate level.
217 – 6. Quality control, maintenance supervision, maintenance control, Minuteman missile cable affairs, maintenance management, administration, and programamobility are staff positions for the deputy commander for maintenance.
217 – 7. The deputy commander for maintenance plans, organizes, coordinates, directs, and controls organizational maintenance.
217 – 8. By delegating authority to the DCM staff.
217 – 9. Production analysis collects and summarizes maintenance data, isolates deficient areas, determines trends, files information, and makes recommendations to the DCM.
217 – 10. A training plan must include instructors for teaching maintenance procedures that will overcome observable weaknesses, must identify the training facility, and must include a test to determine trainee progress.
217 – 11. The administration section.

218 – 1. Inspection, deficiency analysis, deficiency reporting, evaluation, and to file.
218 – 2. Technical, activity, and special inspections.
218 – 3. Study reports, investigate problems, make recommendations, demonstrate methods, follow up plans, etc.
218 – 4. Through personnel evaluations.
218 – 5. By reporting the deficiency to the appropriate command on a deficiencies standard form.

219 – 1. Job control, plans and scheduling and documentation and materiel control.
219 – 2. Job control determines work priorities, assigns job control numbers for maintenance documentation, monitors and controls maintenance vehicles, and coordinates planning decisions with other staff functions.
219 – 3. Minor-fix (unscheduled) maintenance.
219 – 4. Plans and scheduling and documentating.
219 – 5. Materiel control.
219 – 6. Maintenance supply liaison.
219 – 7. Materiel control.
219 – 8. Materiel control primarily, but all others should likewise be concerned.

220 – 1. Maintenance supervisor and workcenter supervisor.
220 – 2. Directing the maintenance for workcenters, stressing the use of safe procedures, informing the DCM of work status, and monitoring the duties of the supervisors at the workcenters.
220 – 3. Coordinating with other supervisors, managing materiel, leading and assisting workers, correcting workers when they are using improper procedures, and reviewing directives.

221 – 1. Collection and analysis of records.
221 – 2. It can reveal wasted manhours, poor manpower assignments, jobs that require the most time, average time needed for jobs, types of maintenance performed, poor quality components, potential trouble spots, and costs to the organization.
221 – 3. Determination of equipment that may need modifying and identification of manpower overages, shortages, or improper assignments.

222 – 1. Standard Form 368.
222 – 2. DD Form 173.
222 – 3. Name of receiving and reporting organizations, date of report, item identification, description of fault, number of like items that have failed, number of items in stock, action taken to correct the difficulty, etc.

223 – 1. Local Communications Service Record.
223 – 2. Telephone Equipment Key System Record/Worksheet.
223 – 3. Class of service for the telephone and quantity of materiel required and used.
223 – 4. Each station has the HOLD and INTERCOM features.

CHAPTER 4

224 – 1. I—catastrophic.
224 – 2. High-voltage or high-current electrical circuits, pole climbing; etc.
224 – 3. Critical hazard.
224 – 4. Pole climbing.
224 – 5. Marginal and negligible.
224 – 6. Screwdriver.
224 – 7. Failure to post occupational safety and health-related materials on bulletin boards.

225 – 1. Electrical Safety gloves.
225 – 2. All such workers should know the proper treatment for electrical shock.
225 – 3. Use screwdrivers only for tightening or loosening screws, and hold them upright.
225 – 4. Only a suitable wrench. The use of pliers results in damage to the nut and to the plier jaw serrations and possibly to your hands.
225 – 5. You can tell a good repair specialist by the clean work area, especially after finishing the job. Tools are in good condition, all of them are authorized, and she or he uses them properly.
225 – 6. Placing ladders too close or too far from a building and leaning too far to attempt to reach what they want. To prevent the first violation, place the foot of the ladder approximately 1/4 the ladder's length from the building. To prevent a fall from reaching too far, descend the ladder and move it closer to the area where you want to work.
225 – 7. 9 to 10 inches.
225 – 8. Look for steps that have loosened to a slope more than 55–60 degrees and for rough burrs that could cause a misstep.

226 – 1. Fire, equipment damage, and personnel injury.

226 – 2. Turn off the electrical switches to the circuit never modify an electrical circuit without supervisory approval, and always have a safety advisor present when you work on high-voltage circuits.
226 – 3. Use insulated tools and/or protective gloves and remove or cover all jewelry and metal devices.
226 – 4. Be sure that all electrical tools and test equipment are grounded before using them.
226 – 5. Muscle paralysis keeps you from releasing the conductor.
226 – 6. The safety procedures that relate to electrical shock and the applicable first aid treatment and closed chest heart message procedures.
226 – 7. Stand where you can see all workers at the equipment, yet be near the main power switch; Also, he must warn all personnel of the potential danger.

227 – 1. A modification or regulation that will prevent a future accident of the same type.
227 – 2. An accident report form requires: name of person or names of people involved; location, date, description of accident; reasons for accident; and type of damage or injury.
227 – 3. Accident/incident report.
227 – 4. Each form requires information about:
  a. Location.
  b. Description.
  c. Date of report.
  d. Name of investigator(s).
227 – 5. By publishing safety standards for equipment and personnel in Air Force publications.

228 – 1. Cleanliness.
228 – 2. Gouged area.
228 – 3. Binding or excessive play of the movable parts.
228 – 4. Frayed cord and damaged ground prong.
228 – 5. Roughened leather, loose rivets, and worn metal parts.

228 – 1. Battery.
229 – 2. Meter.
229 – 3. Low voltage.
229 – 4. Bent needle and cracked glass.

230 – 1. Scraps of wire on the floor and tools lying where they can fall.
230 – 2. Don't permit soda and coffee drinks near telephone equipment, and place all dirty rags in cans with self-closing lids.

231 – 1. TOs 00–5–1 and 00–5–2.
231 – 2. 2 in the second position of the number.
231 – 3. Index technical orders.
231 – 4. TO 31P–2–176WC–1 is an abbreviated technical order (WC) on organizational maintenance (–2).
231 – 5. Use the index technical order to find your reference, and then use the technical manual for operating and maintenance instructions.

232 – 1. TO 0–1–14.
232 – 2. 21.
232 – 3. *Circuit Diagrams—302 Switching Unit, Radar Set, Type AN/CPN-4 and LDG Control Set, Type AN/MPN- 11.*
232 – 4. Preventive maintenance tasks are listed in TO 31P5–2–186WC–1.
232 – 5. Information about the test set used for applying current to relays will be found in a technical order beginning with the number 33A1–12.

233 – 1. Receiving data, material handling, and cable requirements.
233 – 2. Chapter 3, Section 1.
233 – 3. Page 2-20.

234 – 1. AFTO Form 22.
234 – 2. Emergency, urgent, and routine.
234 – 3. The identify of the deficient technical order, the page having the defect, a description of the defect, a recommendation for correction of or improvement of the error, etc.

235 – 1. Monitor the maintenance workcenter's work for adequacy, advise the chief of maintenance of the status of maintenance, and determine causes of problems and probable corrective actions.
235 – 2. Class B.
235 – 3. AFR 0–2.

1985-544-008/20322 AUGAFS,AL(853987)800

STOP - 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

36254 02 23
TELEPHONE CONSTRUCTION AND REPAIR

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet .
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

Note to Student: Consider all choices carefully and select the best answer to each question.

1. (200) When the carbon granules in a telephone handset transmitter are pressed together, the

   a. current through the transmitter decreases.
   b. voltage across the transmitter increases.
   c. resistance of the transmitter decreases.
   d. resistance of the transmitter increases.

2. (201) Pole pieces and a varistor are in the

   a. carbon-cup transmitter.
   b. differential transmitter.
   c. handset receiver.
   d. telephone network.

3. (202) On the three-winding induction coil, two of the windings are called the primary and secondary. The third winding is called the

   a. P2 winding.
   b. S2 winding.
   c. sidetone winding.
   d. balancing winding.

4. (202) Refer to text figure 1-3. Which of the induction coil winding(s) will act in parallel with the receiver and the hookswitch connected to point R?

   a. Primary and secondary.
   b. Secondary and tertiary.
   c. Primary.
   d. Tertiary.

5. (202) One of the main functions of telephone capacitors is to

   a. pass direct current through the ringer.
   b. pass direct current through the receiver.
   c. block the passage of alternating current through the ringer.
   d. block the passage of direct current through the ringer.

6. (202) Sidetone reduction for the circuit of text figure 1-3 is provided by the

   a. switch between terminals L2 and T.
   b. switch between terminals GN and R.
   c. capacitor connected to terminal L2.
   d. capacitor between terminals C and T.

7. (203) In a common-battery telephone system, the electrical power for telephone transmission is furnished by

a. the central officer.
b. batteries in each telephone set.
c. batteries in each telephone set and the central officer.
d. rectifiers in each telephone set and the central office.

8. (203) A common-battery telephone station has

a. batteries, a dial, and a switchboard.
b. a dial, a switchboard, and a ringer.
c. a ringer, a transmitter, a receiver, and a hookswitch.
d. signal lamps, a ringing machine, and a transmitter and receiver.

9. (203) When a subscriber lifts the handset from the cradle of a manual common-battery telephone, the hookswitch

a. connects tone to the switchboard lamps.
b. connects ringing current to signal the operator.
c. completes a circuit that signals the called telephone.
d. completes the circuit to a signal lamp on the switchboard.

10. (204) The two Air Force owned electromechanical telephone switching systems are

a. Western Electric electronic equipment.
b. Western Electric crossbar equipment.
c. XY and Strowger crossbar equipment.
d. XY and Strowger stepping equipment.

11. (204) For the automatic telephone system, the remote control from the central office switching equipment is

a. a switch train.
b. the linefinder.
c. the connector.
d. the dial.

12. (204) With the step-by-step dial system, the wipers of the stopping switches are moved by the action of

a. electromagnets.
b. magnetic impulse counters.
c. electromechanical switches.
d. electromechanical impulse counters.

13. (204) With a manual common-battery system, the switchboard operator completes the connection to a called station by using the

a. call cord.
b. answer cord.
c. selector switch.
d. linefinder switch.

14. (204) The Strowger switch exchange includes linefinder, selector, and

a. hookswitches.
b. connector switches.
c. TALK/RING switches.
d. trunk switches.

15. (204) Strowger switch connections are made by

a. cords at jacks.
b. wipers at bank terminals.
c. East positioned wipers against North positioned terminals.
d. mounted silver contacts rotating horizontally against flexible springs.

16. (204) The switch of text figure 2-2 has

a. line wipers for connecting with vertical bank terminals.
b. line wipers for connecting with horizontal bank terminals.
c. vertical wipers for connecting with lower horizontal bank terminals.
d. vertical wipers for connecting with upper horizontal band terminals.

17. (204) If the number 74 were dialed into the stepping switch of any XY dial system, the switch wiper would take

a. 4 steps in the X direction and then 7 steps in the Y direction.
b. 7 steps in the X direction and then 4 steps in the X direction.
c. 4 steps in the Y direction and then 7 steps in the X direction.
d. 7 steps in the Y direction and then 4 steps in the X direction.

18. (204) Text figure 2-4 shows that the X-XX wipers move in the

a. X direction into the T-R bank during X stepping.
b. X direction into the S-HS bank during Y stepping.
c. Y direction into the X-XX bank during X stepping.
d. Y direction into the X-XX bank during Y stepping.

19. (204) The contact banks for an XY switch include

a. X banks, Y banks, and X-XX banks.
b. Y-YY banks, Y banks, and X banks.
c. X banks, T and R banks, and S and HS banks.
d. X-XX banks, T and R banks, and S and HS banks.

20. (205) When the digit 4 is dialed by a telephone subscriber, the dial pulsing springs interrupt the line circuit

a. four times as the dial returns to the normal position.
b. eight times as the dial returns to the normal position.
c. four times as the finger plate is pulled around to the finger stop.
d. twice as the finger plate is pulled around to the finger stop.

21. (205) Refer to figure2-5 of the text. When the dial finger plate is in an OFF-NORMAL position, it is possible to transmit because the

a. line loop is held open.
b. pulse springs are shunted.
c. transmitter circuit is open.
d. transmitter circuit is shunted.

22. (205) In the circuitry shown in figure 2-5 of the text, during dialing the

a. 4-microfarad capacitor is connected directly across the dial shunt springs.
b. 4-microfarad capacitor is connected directly across the dial pulse springs.
c. 07-microfarad capacitor and the 100-ohm resistor form a series circuit across the dial shunt contacts.
d. 0.7-microfarad capacitor and the 100-ohm resistor form a series circuit across the dial pulse contacts.

23. (205) Refer to figure 2-5 of the text. When a subscriber places the handset on the cradle switch, the 0.7 microfarad capacitor and ringer are

a. connected to the pulse springs.
b. removed from the line loop.
c. are connected to the line loop.
d. disconnected from the ringing circuit.

24. (206) Refer to figure 2-6 in the text. Pressing touch-tone key 8 on the TTMF subset connects low-and-high-frequency tones

a. 697 and 1477 to the telephone line.
b. 770 and 1477 to the telephone line.
c. 852 and 1336 to the telephone line.
d. 941 and 1336 to the telephone line.

25. (206) Use text figure 2-6 to determine which of the following tones will be connected to the telephone line following depression of the touch-tone key No. 1.

a. 697.
b. 770.
c. 1336.
d. 1477.

26. (206) Use text figure 2-6 to determine the tone which will be heard following depression of key 4.

a. 697.
b. 852.
c. 1209.
d. 1336.

27. (206) Which of the following operates the relays of the electromechanical telephone switching equipment?

a. Logic information.	c. Pulses.
b. Two tones.	d. A tone.

28. (206) Which of the following telephone set connecting arrangements does not require signal conversion?

a. Touch-tone dial to touch-tone dial.
b. Touch-tone dial to rotary dial.
c. Rotary dial to touch-tone dial.
d. Rotary dial to rotary dial.

29. (206) Electronic telephone systems convert signals between touch-tone stations and rotary dial stations with

a. linefinder equipment.	c. precedence units.
b. two-wire equipment.	d. interface equipments.

30. Refer to figure 2-7 of the text. When the subscriber removes the handset from its cradle, causing the hookswitch contacts to close, the circuit taken operates

a. relay A and the magnets.	c. relay A and relay B.
b. relay B and the magnets.	d. relay A, relay B, and the magnets.

31. (207) When the telephone subscriber dials digit 2, the dial pulsing springs open, and the line circuit closes in which of the following sequence?

a. Make, break, make, break.	c. Make, break, break, make.
b. Break, make, break, make.	d. Break, make, make, break.

32. (207) In the example circuit of text figure 2-7, the dialed digit 3 does which of the following?

a. Pulses the A relay three times.
b. Pulses the B relay three times.
c. Pulses the A and B relays each three times.
d. Steps the DTMF oscillator by means of the magnets.

33. (208) As the dial finger plate is pulled around to the finger stop during dialing, the energy for returning the dial mechanism is provided by

a. a friction type pawl.	c. the governor.
b. the back stop.	d. a spring.

34. (208) The principal function of the dial governor is to

a. control the dial drive spring.
b. control the return speed of the dial.
c. return the dial mechanism to the unoperated position.
d. control the number of times the pulse pawl strikes the pulsing springs.

35. (208) When using a dial speed tester to test the speed of a telephone dial, the readings obtained are based on

a. digits per second.
b. cycles per second.
c. pulses per second.
d. revolutions per second.

36. (208) In the circuits shown in figure 2-9 of the text, the hookswitch contacts between terminals L2 and L1 complete the circuits through the

a. tertiary winding and capacitor.
b. balancing winding.
c. primary winding and transmitter.
d. secondary winding and transmitter.

37. (208) In figure 2-9 of the text, the receiver circuit is

a. shorted out by dial contacts 5 and 6.
b. shorted out by dial contacts 3 and 4.
c. completed through dial contacts 3 and 4.
d. completed through dial contacts 5 and 6.

38. (208) Refer to figure 2-9 of the text. When the dial pulse springs contacts 1 and 2 are open, line current is

a. shunted through the transmitter.
b. opposed by radio current.
c. interrupted.
d. activated.

39. (209) The handset cord used with the 500 telephone normally has

a. two conductors and a shield.
b. two conductors only.
c. three conductors only.
d. four conductors.

40. (209) In the handset used with the 500 telephone, the conductors of the handset cord are connected to

a. both the transmitter and receiver by spring contacts.
b. both the transmitter and receiver by screw terminals.
c. the transmitter by spring contacts and to the receiver by terminal screws.
d. the receiver by spring contacts and to the transmitter by terminal screws.

41. (209) In comparison with older units, the transmitter used with the 500 telephone provides a better quality of transmission because of a

a. special treatment given to the carbon granules.
b. special arrangement of the connecting diaphragm.
c. pair of silver contacts that engage the carbon granules.
d. ribbed diaphragm located back of the upper membrane.

42. (209) Refer to figure 2-11 of the text. When the handset of a 500 telephone is on its cradle, hookswitch contacts

a. A and B open the receiver circuit.
b. F and G open the receiver circuit.
c. A and B short out the receiver circuit.
d. F and G short out the receiver circuit.

43. (209) What is the function of the shunt contacts for the dial of the 500 telephone?

a. Open the receiver circuit during dialing.
b. Open the transmitter circuit during dialing.
c. Short out the receiver circuit during dialing.
d. Short out the transmitter circuit during dialing.

44. (209) There are seven basic components required in a 500 telephone. Which one of the following components is not required?

a. Ringer.
b. Capacitor.
c. Generator.
d. Hookswitch.

45. (210) When installing telephone wiring in a house, the installer will normally

a. use a red wire for the tip side of the circuit.
b. use a green wire for the ring side of the circuit.
c. connect the red wire to the right-hand terminal of the connecting block.
d. connect the green wire to the right-hand terminal of the connecting block.

46. (211) Refer to figure 2-15 of the text. If a given half-cycle of ringing current is entering the circuit via the ring conductor and returning to the central office over the tip conductor, it must pass through the

a. 1,000-ohm ringer coil in a direction from terminal G to terminal K.
b. 1,000-ohm ringer coil in a direction from terminal K to terminal G.
c. 2,650-ohm ringer coil in a direction from terminal A to terminal L2.
d. 2,650-ohm ringer coil in a direction from terminal L1 to terminal L2.

47. (211) As shown by the circuitry in figure 2-15 of the text, the yellow conductor in the mounting cord is used to complete the

a. talking circuit between the tip conductor and the network.
b. receiving circuit between the tip conductor and the network.
c. ringing circuit between the tip conductor and the network.
d. dialing circuit between the tip conductor and the network.

48. (211) In figure 2-15 of the text, which one of the following circuits is connected to the line terminals regardless of hookswitch position?

a. The ringer circuit.
b. The receiver circuit.
c. The primary circuit.
d. The secondary circuit.

49. (212) As illustrated by figure 2-17 of the text, battery current from the central office flows from network terminal

a. R to network terminal RR via winding P1.
b. RR to network terminal R via winding P1.
c. B to network terminal C via winding P2 and resistor R1.
d. RR to network terminal B via winding P1 and the transmitter.

50. (212) Tracing the circuit of text figure 2-17, which of the following contact conditions makes transmitting and receiving possible?

a. Pulse contacts of the dial must be open.
b. Pulse contacts of the dial must be closed.
c. Off-normal contacts of the dial must be closed.
d. Off-normal and pulse contacts of the dial must be closed.

51. (212) When transmitting with a common-battery telephone, the sound waves entering the transmitter cause the resistance to vary, which, in turn, causes a flow of

a. ac in the transmitter and primary winding.
b. dc in the secondary winding.
c. varying dc in the transmitter and primary winding.
d. varying ac in the transmitter and primary winding.

52. (212) Since terminal L1 in figure 2-15 is connected to the tip side of the line and terminal L2 is connected to the ring side, the dc current will flow through the induction coil from terminal

a. R to terminal L1.
b. R to terminal GN.
c. G to terminal R.
d. GN to terminal R.

53. (212) During transmission with the telephone circuitry illustrated in figure 2-15 of the text, the voice currents in

a. winding P1 are aided by those in winding S1.
b. winding P1 are opposed by those in winding S1.
c. both of the primary windings aid each other by inducing additive currents.
d. both of the primary windings oppose each other by inducing opposing currents.

54. (213) During receiving with the telephone circuitry illustrated in figure 2-17 of the text, the voice currents that flow to the receiver are induced in which of the following windings?

a. P1.
b. P2.
c. S1.
d. S2.

55. (214) During transmission, with a circuit such as illustrated in figure 2-17, the antisidetone circuit reduces sidetone because

a. a closed path is provided for magnetic lines of force between the windings of the induction coil.
b. the current in one induction coil winding is opposite to that in the other windings.
c. the current in the primary winding is in the same direction as that in the other windings.
d. the current in the transmitter is alternating current during transmission.

56. (214) While transmitting with the 500-type telephone, (see fig. 2-17) a decrease in transmitter resistance will cause

a. an increase in the current through network windings P1, P2, and S2.
b. an increase in the current through network windings P1, P2, and S1.
c. a decrease in the current through windings P1 and P2 and an increase in the current through winding S2.
d. a decrease in the current through windings P2 and S2 and an increase in the current through winding P1.

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57. (214) While transmitting with the 500-type telephone (see fig. 2-17), the voice currents induced in network winding

a. S1 by windings P1 and P2 are out of phase with the current induced in S1 by winding S2.
b. S1 by windings P1 and P2 are in phase with the current induced in S1 by winding S2.
c. S1 by windings in P1, P2, and S2 are all additive currents.
d. S1 by windings P2 and S2 are all additive currents.

58. (215) Text figure 2-25 shows that the receiver is

a. shorted during dialing by the OFF-NORMAL dial contacts.
b. shorted during dialing by the dial PULSE contacts.
c. opened during dialing by the dial OFF-NORMAL springs.
d. opened during ringing by the dial PULSE springs.

59. (216) The same basic parts and circuits are in

a. all 500 telephones.
b. the 500 series keysets.
c. the 600 series call directors.
d. all of the above.

60. (216) Explosionproof telephones may be used in areas exposed to combustible gas because their

a. network parts are gasproof.
b. hookswitch contacts have been eliminated.
c. internal parts are designed to eliminate arcing.
d. internal parts are inclosed in a gasproof housing.

61. (216) The network hookswitch, dial, ringer, transmitter and receiver, and their associated components in a weatherproof telephone are

a. the same as the components in the 500 series telephone.
b. bound together with cast aluminum conduit.
c. individually inclosed in conduit.
d. plug-in units, thus portable for use with any weatherproof set.

62. (217) Replacement of the plug-in type J53033A key and lamp unit at an operator's van is

a. depot-level maintenance.
b. intermediate-level maintenance.
c. organizational-level maintenance.
d. base-level maintenance.

63. (217) Organizational maintenance is

a. notification of circuits.
b. modification of parts.
c. technical assistance.
d. routine repair.

64. (217) Modification of a circuit card is normally a function of

a. each system specialist.
b. depot-level maintenance.
c. organizational level maintenance.
d. the manufacturers.

65. (217) A calibration check on an AN/PSM-6 multimeter is

a. organizational-level maintenance.
b. intermediate-level maintenance.
c. a requirement of T.O. 00-35D-54.
d. a base-level maintenance.

66. (217) Mobile maintenance shop specialists are

a. assigned to 3-level airmen.
b. assigned to depot-level maintenance.
c. assigned to intermediate-level maintenance.
d. restricted to adjusting rheostats and relays.

67. (217) Key system power supplies are

a. repaired by depot maintenance.
b. modified by organizational technicians.
c. evaluated by the administration section.
d. changed by production analysis.

68. (217) Manpower requests for a communications maintenance organization are justified by

a. intermediate-level management.
b. the deputy commander for maintenance.
c. depot-level management.
d. each crew chief.

69. (217) AFM 66-1 is best described as being

a. management directives.
b. a training publication.
c. classified directives.
d. a supplementary reference.

70. (217) Using text figure 3-1, which of the following units is a section under the deputy commander for maintenance?

a. Maintenance information system.
b. Command headquarters.
c. Production analysis.
d. Supply squadron.

71. (217) Maintenance data summation and interpretation is the function of

a. production analysis.
b. training management.
c. shop supervisors.
d. crew chiefs.

72. (217) Which of the following tasks is performed by training management?

a. Files MAR forms.
b. Supervises testing.
c. Monitors bench stock.
d. Inspects activity reports.

73. (217) Information for the chief of maintenance is

a. classified and stored in walk-in vaults.
b. recorded and filed by the administration section.
c. programmed for computers in the programs-mobility section.
d. periodically updated by the maintenance supervisor and filed in the technical order library.

74. (218) Within quality control, the role of investigating 302 communications equipment for compliance with technical changes is a responsibility of the

a. inspection function.
b. programs-mobility section.
c. producation analysis section.
d. standardization-evaluation section.

75. (218) Quality control record filing procedures are

a. listed in AFM 66-1.
b. included in an activity inspection.
c. included in a technical inspection.
d. described in the 00-20 technical order series.

76. (218) Evaluation standards are developed from information provided by the

a. maintenance control unit.
b. quality control unit.
c. production analysis section.
d. programs-mobility section.

77. (218) To report an error in a technical order schematic, use

a. AFTO 1075.
b. DAF 349.
c. SF 110.
d. AFTO 22.

78. (219) Job control, plans and scheduling, and materiel control are sections of

a. quality control.
b. maintenance control.
c. production control.
d. program-mobliity.

79. (219) The responsibility for insuring that schedules are not interrupted because of lack of components, maintenance tools, and equipment is assigned to

a. materiel control.
b. deficiency analysis.
c. quality control.
d. production analysis.

80. (219) Emergency repair is considered to be which of the following?

a. A minor-fix action.
b. Scheduled maintenance.
c. Unscheduled maintenance.
d. Repair which is never documented with JCDs.

81. (219) Which one of the listed factors should be considered when planning each day's activities?

a. Personnel skills.
b. Future historical report contents.
c. Test equipment calibration results.
d. Component discrepancy report results.

82. (219) Documentation job control numbers are determined and assigned by

a. the workcenter supervisor.
b. job control in maintenance control.
c. the deputy commander for maintenance.
d. Plans and scheduling.

83. (219) All maintenance activities are kept informed of their overall supply situation by

a. materiel control.
b. base supply.
c. evaluation.
d. quality control.

84. (219) The number of spare telephone networks to have on-hand is

a. forecasted by maintenance supply liaison of materiel control.
b. requested by maintenance supply liaison of quality control.
c. requested by organizational supply support of quality control.
d. authorized by job control and documented by the maintenance superintendent.

85. (220) Observing the test results at a test point and advising the shop team of its discrepancy is the task of

a. training management.
b. deficiency analysis.
c. the workcenter supervisor.
d. the chief of maintenance.

86. (221) How are maintenance records kept current?

a. With biannual code changes.
b. By collecting and submitting data hourly.
c. By using standardized information from files.
d. By workcenter supervisors providing daily information.

87. (221) Which of the following is a function of management?

a. Install telephone sets.
b. Replace KTU components.
c. Analyze maintenance information and identify manpower needs.
d. Consult technicians and demonstrate correct maintenance procedures.

88. (221) Good maintenance management requires that maintenance information be accurate, presented in a prescribed format, and

a. submitted at a specified time.
b. accompanied by justification information.
c. explained in an accompanying document.
d. used as the manpower authorization.

89. (221) Good maintenance management results from

a. security restriction control.
b. analysis and comparison of equipment operation reports.
c. cross utilization of personnel.
d. an excessive number of outages.

90. (221) One important factor to consider when analyzing maintenance summary reports is

a. number of man-hours expended.
b. safety.
c. priorities.
d. problem workers.

91. (221) Analysis of the use of manpower reveals to a supervisor that

a. a yearly budget should be estimated high enough to overcome the unexpected raises.
b. more time is needed for work evaluation.
c. the best trained people are underpaid.
d. a workcenter is manned correctly or incorrectly.

92. (222) The procedures to use when reporting equipment deficiencies are outlined in

a. AFM 66-1.
b. TO 00-35D-54.
c. TO 00-20-2-2.
d. TOs 00-5-1 and -2.

93. (222) Which one of the following terms is used to identify a nonemergency deficiency?

a. Category II.
b. Technical.
c. Minor.
d. Shunt.

94. (222) If the same capacitor for many telephones fails after 100 hours of use, what form should be used to report this deficiency?

a. AFTO 22.
b. AFTO 110.
c. AFTO 122.
d. Quality deficiency.

95. (223) Documentation for installing a telephone is

a. filed in technical order binders while current.
b. contained on the Local Communications Service Order.
c. destroyed by the installer as he completes each project.
d. requested on the AF 1070 Local Communications Service request form.

96. (223) The document that provides you the authority to install a telephone for a new subscriber is the

a. AF 1075, Local Communications Service Order.
b. AF 1077, Telephone Service Record.
c. AFTO 122, Telephone Equipment Key Systems Record/Worksheet.
d. AF 2447, Telephone Trouble Log.

97. (223) Figure 3-2 shows that the installer must consider the telephone location, the wire connections, and the

a. materials.
b. materials costs.
c. monthly charges.
d. cable records distribution data.

98. (223) What listed information is normally included on a Local Communications Service Order (AF 1075 Form)?

a. Type telephone equipment to be installed.
b. Class of service.
c. Service location.
d. All of the above.

99. (224) What hazard category is a weakened telephone pole?

a. Marginal or negligible.
b. Catastrophic or critical.
c. Catastrophic and marginal.
d. Critical and marginal.

100. (224) What is the hazard category of corroded 44A block terminals?

a. Critical.
b. Negligible.
c. Marginal.
d. Catastrophic.

101. (225) Identify the procedures in the safe use of an electrical drill.

a. Apply and remove pressure alternately.
b. Hold it at a 45 degree angle when drilling.
c. Stand on insulated matting when drilling the hole for the drive hook.
d. Drill above a catch-basket tarp to prevent wood chip injury observers.

102. (225) From the following list of statements, select the one that is a safety violation when using a ladder.

a. Stand no higher than the third highest rung for working at high levels.
b. Step to the highest rung position for working at high levels.
c. Lift the leg up one step at a time.
d. Always overlap extension sections.

103. (225) Proper pole step separation is

a. 9-10 inches.
b. 7-8 inches.
c. 4-6 inches.
d. 18-20 inches.

104. (226) The factors that cause electrical shock are

a. cleanliness and corrosion.
b. current and voltage.
c. low impedance and high resistance.
d. high-resistance units and low-voltage terminals.

105. (226) When preparing to troubleshoot near the 101G power unit,

a. remove the line fuse and disconnect the AC cord.
b. review the artificial respiration instructions.
c. ensure that the safety observer is in position and ready.
d. ground the equipment shield with a three-prong adapter.

106. (227) Information to be included on an accident report is: person(s) involved, date, description, injury, and

a. recommended treatment.
b. safety devices used.
c. safety devices available.
d. place of accident.

107. (227) Completion of a site hazard report should include

a. counsel with the ground safety officer and the security police.
b. a recommendation for correcting the hazard.
c. a change to AFR 127-101.
d. a change to AFR 127-4.

108. (228) Tools in each telephone installer's kit are

a. inspected daily by QC.
b. insulated.
c. cleaned and oiled daily.
d. authorized.

109. (229) Care of multimeters includes daily inspection for condition, shock protection, proper storage, and

a. scheduled calibration by QC.
b. scheduled calibration by PMEL.
c. unscheduled calibration by QC.
d. unscheduled calibration by PMEL.

110. (230) A good housekeeping practice is to

a. place oily and dirty rags in self-closing covered cans.
b. separate combustible items, then store them in isolated areas.
c. limit cigarette disposal to covered metal containers.
d. do all of the above.

111. (230) Which of the following best supports good housekeeping practices?

a. Firm control and repetitious advice.
b. Cleanliness and inspections.
c. Continuous study and critical evaluation.
d. Critical analysis and responsive advice.

112. (231) What type technical order is TO 31P5-2-182?

a. TCTO.
b. Abbreviated.
c. Index.
d. Organization maintenance.

113. (231) Using text figure 5-2, identify the technical order that is an abbreviated type.

a. 31P5-2-184C.
b. 31P5-2-176WC-1.
c. 31P5-2-183D.
d. 31P5-2FPN16-2SS-1.

114. (232) Of the following technical orders, which is an index type?

a. 0-1-31.
b. 00-5-2.
c. 31P5-2-184.
d. 31P5-2-176WC-1 .

115. (232) Which of the listed technical order numbers designates the numerical index of technical order indexes?

a. 00-5-1.
b. 0-2-1.
c. 0-1-01.
d. 00-20-1.

116. (232) Use text figure 5-2 to identify the technical order that pictorially illustrates components of the 302 switching unit?

a. 31P5-2-184.
b. 31P5-2-566.
c. 31P5-2-176S-1.
d. 31P5-2-186WC-1.

117. (232) The change number and date for TO 31P5-2-182 is (see text fig. 5-2)

a. Chg 5, 15 Feb 62.
b. Chg, 9, 31 Jan 62.
c. Chg 5, 12 Oct 78.
d. Chg 9, 19 Aug 77.

118. (232) Text figure 5-3 shows the title of the test equipment technical order group as "Wave Form Measuring Equipment." What is the category number for this equipment?

a. 33A1-13.
b. 33A1-14.
c. 33A1-15.
d. 33A1-5.

119. (233) Refer to text figure 5-5. Cable assembly ED69450-31 has

a. a REQ & ACK and 3 POS cables between the power and operations vans.
b. a REQ & ACK and 3 POS cables installed between the two runway sites.
c. two input assemblies.
d. six phone lines.

120. (234) To suggest a change to a technical order, use

a. AFTO 110.
b. AFTO 22.
c. AF 991.
d. AF 2447.

121. (234) Technical order deficiency reporting instructions are in

a. AFR 66-1, Volume 5.
b. TO 00-35D-54.
c. TO 00-5-1.
d. AFM 100-22.

122. (234) In the summarizing block of a submitted AFTO Form 22, which type of information is included?

a. Recommended change.
b. Federal stock number.
c. NI & RT coordination symbol.
d. Trouble symptom.

123. (235) The Government telephone that has access to AUTOVON trunks is

a. class B.
b. class A.
c. red and in the base commander's office only.
d. black and in the base commander's office only.

END OF EXERCISE

STUDENT REQUEST FOR ASSISTANCE

PRIVACY ACT STATEMENT

AUTHORITY: 10 USC 8012 and EO 9397. **PRINCIPAL PURPOSES:** To provide student assistance as requested by individual students. **ROUTINE USES:** This form is shipped with ECI course package. It is utilized by the student, as needed, to place an inquiry with ECI. **DISCLOSURE:** Voluntary. The information requested on this form is needed for expeditious handling of the student's need. Failure to provide all information would result in slower action or inability to provide assistance to the student.

SECTION I: CORRECTED OR LATEST ENROLLMENT DATA: *(Mail to: ECI, Gunter AFS AL 36118)*

1. THIS REQUEST CONCERNS COURSE (1 - 6)	2. TODAY'S DATE	3. ENROLLMENT DATE	4. AUTOVON NUMBER
5. SOCIAL SECURITY NUMBER (7 - 15) ☐☐☐ - ☐☐ - ☐☐☐☐	6. GRADE/RANK	7. NAME *(First initial, second initial, last name)* (17) (18) (19-32)	
8. ADDRESS *(OJT Enrollees – Address of unit training office with zip code. All others – current mailing address with zip code.)*	(33-53) (54-75)		
9. NAME OF BASE OR INSTALLATION IF NOT SHOWN ABOVE		10. TEST CONTROL OFFICE ZIP CODE/SHRED (33 - 39)	

SECTION II: REQUEST FOR MATERIALS, RECORDS, OR SERVICE

(Place an 'X' through number in box to left of service requested)

1	Request address change as indicated in Section I, Block 8.
2	Request Test Control Office change as indicated in Section I, Block 10.
3	Request name change/correction (Provide Old or Incorrect data)
4	Request Grade/Rank change/correction.
5	Correct SSAN. (List incorrect SSAN here) (Correct SSAN should be shown in Section I)
6	Extend course completion date. (Justify in REMARKS)
7	Request enrollment cancellation. (Justify in REMARKS)
8	Send VRE answer sheets for Vol(s): 1 2 3 4 5 6 7 8 9 Originals were: ☐ Not received ☐ Lost ☐ Misused
9	Send course materials. (Specify in REMARKS) ☐ Not received ☐ Lost ☐ Damaged
10	Course exam not yet received. Final VRE submitted for grading on ______________ (date).
11	Results for VRE Vol(s) 1 2 3 4 5 6 7 8 9 not yet received. Answer sheet(s) submitted ______________ (date).
12	Results for CE not yet received. Answer sheet submitted to ECI on ______________ (date).
13	Previous inquiry (☐ ECI Fm 17, ☐ Ltr, ☐ Msg) sent to ECI on ______________ (date).
14	Give instructional assistance as requested on reverse.
15	Other (Explain fully in REMARKS)

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K	Vol 33 - 35	GR 36 - 38
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N	33 - 38	
P	Vol 33 - 35	
	TC 36 - 37	38
	DOE 38 - 45	
Q	33 - 34 QQ	38 1
	MC 39 -42	

REMARKS *(Continue on Reverse)*

OJT STUDENTS must have their OJT Administrator certify this request.	I certify that the information on this form is accurate and that this request cannot be answered at this station. *(Signature)*
ALL OTHER STUDENTS may certify their own requests.	

ECI FORM OCT 83 17 (PREVIOUS EDITIONS MAY BE USED)

SECTION III: REQUEST FOR INSTRUCTOR ASSISTANCE

NOTE: Questions or comments relating to the accuracy or currency of subject matter should be forwarded directly to preparing agency. For an immediate response to these questions, call or write the course author directly, using the AUTOVON number or address in the preface of each volume. All other inquiries concerning the course should be forwarded to ECI.

VRE Item Questioned:

Course No __________

Volume No __________

VRE Form No ________

VRE Item No ________

Answer You Chose ______ (Letter)

Has VRE Answer Sheet been submitted for grading?

☐ Yes ☐ No

REFERENCE

(Textual reference for the answer I chose can be found as shown below)

In Volume No __________

On Page No __________

In ☐ left ☐ right column

Lines ____ Through ____

MY QUESTION IS:

REMARKS

ADDITIONAL FORMS 17 available from trainers, OJT and Education Offices, and ECI. Course workbooks have a Form 17 printed on the last page.

36254 03 8102

CDC 36254

TELEPHONE EQUIPMENT INSTALLATION AND REPAIR SPECIALIST

(AFSC 36254)

Volume 3

Substation Installation

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Air University

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DEPARTMENT OF THE AIR FORCE
UNITED STATES OF AMERICA
MCMXLVII

3750 TECHNICAL TRAINING GROUP
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EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

AS AN installation and repair specialist, you are responsible for placement and care of telephone station apparatus used by the Air Force. Having completed Volumes 1 and 2 of this course, you reviewed telephone system principles and telephone instruments and noted some management principles. However, very little has been said yet about connecting the telephone to a cable or line or about the installation of station wiring and apparatus.

This volume reviews telephone installation principles and includes information on the materiels and attachments used in connecting telephones and associated apparatus. In addition, we have a brief coverage of team management. We emphasize, here, that the procedural steps given are used only to illustrate our presentation of principles. Your authorized installation of telephone equipment must follow the approved procedures used by your organization. The maintenance coverage consists of information on preventive maintenance and corrosion control, plus trouble isolation, location and elimination.

Although some of the materials illustrated and described in this volume may not be in the most recent installations, it is quite probable that you will see and be responsible for them in some existing installation. They are included in the volume because we believe that you should be familiar with the former and the newer installation apparatus and procedures if you're to be an efficient installation and repair specialist.

Direct your questions or comments relating to the accuracy or currency of this volume to the course author, 3750 TCHTG/TTKMS, STOP 44, Sheppard AFB, TX 76311. If you need an immediate response, call AUTOVON 736-2088, between 0800 and 1630 (CST), Monday through Friday. (*NOTE: Do not use the suggestion program to submit changes or corrections for this course.*)

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to a Successful Course, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If this person can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This material is valued at 30 hours (10 points).

Material in this volume is technically accurate, adequate, and current as of October 1980.

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NOTE: In this volume, the subject matter is developed by a series of student-centered objectives. Each of these carries a three-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see whether your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Telephone Station Planning

AS A TELEPHONE equipment installation specialist, one of your responsibilities is the installation of telephone equipment. Equipment covered in your career field includes key systems, 302 switch units, AN/GTC–28 switching equipment, and 500-type subsets and associated hardware. However, in this volume, we describe only the installation of the telephone subset and associated hardware. Installation of the other equipment is described in Volume 4. You should know that complete installation of telephone equipment consists of the following steps: installation planning; installation of outside equipment such as poles, terminal cans, drop wire and protector; running of the inside wire; and placement of the instrument.

Chapter 1 provides a brief coverage of telephone station planning. Good planning produces greater efficiency and reduces the cost for an installation which, in turn, reduces the total annual budget of the Air Force. The chapter has been divided into the following sections: (1) Review of the typical telephone system and substation; (2) management planning; (3) materiel planning; and (4) installation planning.

1-1. Review of the Typical Telephone System and Substation

As an efficient telephone equipment installation and repair specialist, you must have a good knowledge of the installation requirements and procedures for a substation and know the components of the system.

400. Identify the telephone system areas and name the area for which an installer-specialist is responsible.

Telephone System Areas. As you can see in figure 1-1, the substation includes that portion of the telephone system which extends from the telephone line down to and including the user's telephone set. As shown in this illustration, the telephone system consists of a central office area, a line area, and a substation area. Although the illustration shows the telephone lines on poles, most lines today are in cables placed underground. One end of the cable terminates at the central office and the other end terminates at a terminal-can or box which is located near the building and housing area on the base.

For overhead lines and cables, the terminal-can is normally located on a pole adjacent to the buildings. When underground cable is used, the terminal-can may be located on a pedestal only a few feet above ground or on a pole in the area. In any case, you are responsible for installing and maintaining the telephone station and the equipment from the terminal-can down to and including the user's telephone.

Exercises (400):

1. What telephone system area has the automatic switching equipment and switchboards?

2. Identify the telephone system area that extends between the central office main frames and the terminating can near the substation area.

3. Name the telephone system area that has the drop wire, the building protector, station ground, inside wire run, connecting block, and 500 telephone subsets.

4. Specify the telephone system area where you will normally perform your tasks and two units which you will install and maintain.

401. For given substation area components, tell where each is located or give its function.

Since we have discussed telephone system areas in general, let us now consider the substation area in more detail.

Substation Area Components. By referring to figure 1-2, you can see the outside portion of a substation.

Drop wire run. The drop wire which extends from the can on the terminal pole to the bracket on the corner of the building is called the drop. The wiring which extends from the bracket on the corner of the building to the protector is

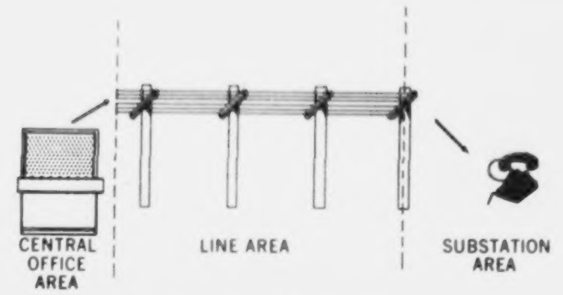


Figure 1-1. Substation area.

called the drop wire run on the building. The entire length of wire from the terminal pole to the protector is the drop wire run.

Protection area. The protector with its ground wire, also shown in figure 1-2, is a lightning arrestor which protects the installation from the high voltages and currents associated with lightning, crosses with power lines, and other conditions. Some of these protectors are equipped with fuses which burn out from excess current. Others may be equipped with carbon blocks which shunt the high voltages to ground. The ground wire serves as a ground for the protector and also as a ground for the telephone circuits on some systems.

Inside wiring. The wiring which leads into the building from the protector is normally referred to as inside wiring. This inside wiring may extend for a considerable distance inside of the building or it may only extend through the wall, as shown in figure 1-3. In any event, you normally terminate it at a connecting block. The connecting block also permits the telephone cord attachment. In figure 1-3 the connecting block is shown just inside the wall from the protector, and the telephone cord is shown connected to the block.

Exercise (401):

1. In the R blank for the component of column A place the letter for the statement of column B that relates to that component. In the F/L blank, place an F if the statement tells the component function or an L if it gives the component's location. Use each letter only once.

Column A

R	F/L	Component
____	____	(1) Terminal-can.
____	____	(2) Drop.
____	____	(3) Drop wire run.
____	____	(4) Protector.
____	____	(5) Fuse.
____	____	(6) Carbon blocks.
____	____	(7) Ground wire.
____	____	(8) Inside wiring.
____	____	(9) Connecting block.
____	____	(10) Telephone cord.

Column B

a. Connects between a protector and the connecting block.
b. Shunts high voltage to ground.
c. Terminates inside wiring and telephone cord.
d. On the pole adjacent to the building.
e. Terminates at terminal-can and the protector.
f. Carries line current to the telephone.
g. Extends telephone pair to pole from building.
h. Reduces high voltages and currents on telephone pair.
i. Attaches to protector and ground rod.
j. Opens a telephone circuit having excess current flow.

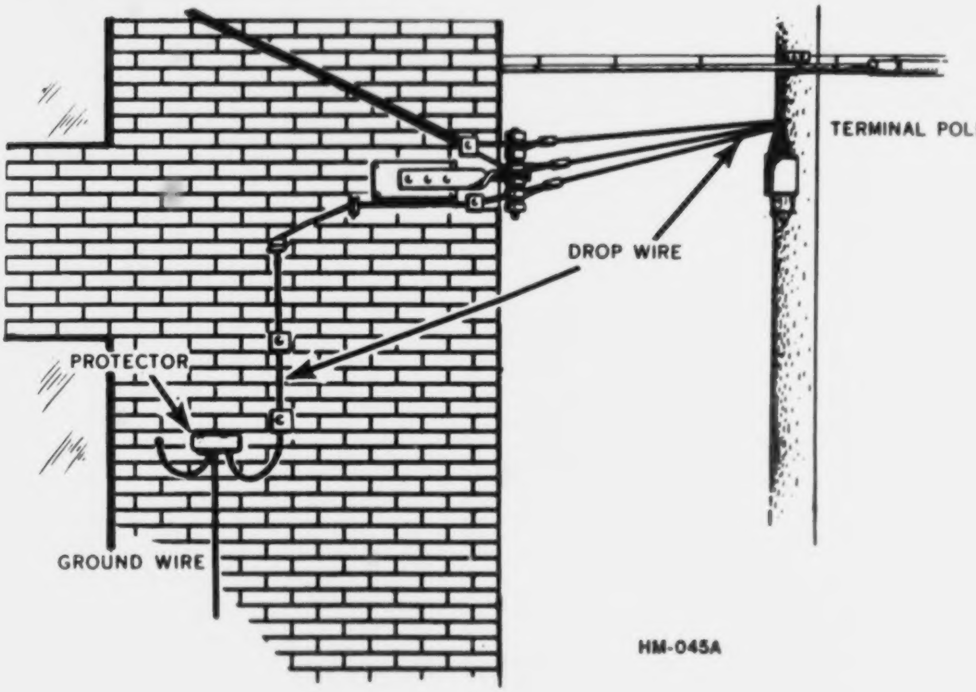


Figure 1-2. Outside portion of substation.

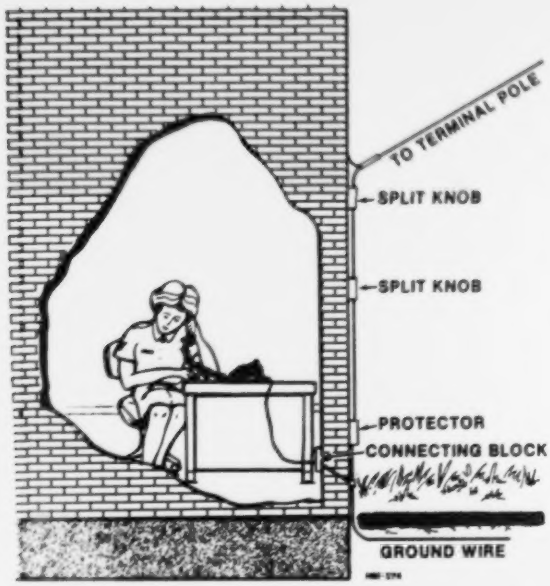


Figure 1-3. Inside portion of substation.

1-2. Management Planning

Management planning may be broad in scope or limited. Its content is determined by the people involved with it. To illustrate, management planning for a telephone installation could include base wire communications program planning, communications system implementation planning, manpower requirements, resource requirements, coordination requirements, work priorities, transportation needs, available team personnel and their experience, and preassignment forecast sponsors, etc. Since your job consists primarily of service as a team member or team leader, we are limiting our discussion to planning management of such a crew.

402. Identify planning tasks for telephone equipment installation personnel.

Plan Requirements. Job preparation includes determining the requirements of the job and studying previous jobs to insure that the requirements are accurate. You must coordinate with job control, maintenance control, the wire chief, and any other supervisor who may be involved in the installation planning and its completion. Also, it includes determining the crew's qualifications and their availability, and making their assignment either to the tasks for which they're qualified or to tasks on which you want them to be trained. In addition, you plan methods for controlling the work. Likewise, planning includes determining the materiel required for the job and that available in bench stock.

Manning Management. We noted above that management planning included determination of the crew's qualifications and their availability. Although manning documents authorize a specified number of people with a certain skill level to your workcenter, that number of people is not always available. Reasons for this are that Air Force personnel are rotated constantly, people are sick, on leave, on TDY, or may have special assignments.

Worker assignment. Your planning, then, includes assigning the workers that you have; or if you need more people, getting approval to add a team member, or members, or adding teams. Your planning also should include the programming of future OJT requirements and locating the records you must complete to show personnel training progress. Telephone equipment is getting more complex each year, and you must be sure your people are trained in in the new or modified equipment. Planning will reduce the need for crash-type training programs.

Planning includes identifying your workers and placing them on a duty roster. Proper placement depends on your knowledge of their abilities and personalities. You must consider the personalities of your team members because people who work well together will complete more work in a shorter period than those who do not. Possible problems for a leader are: Some people resent changes, others want to do just enough to make the equipment operate, another person may want the job completed as specified at a factory, another may have family problems which affect the work quality and the amount that is completed, another may be dissatisfied with base regulations or with the shift rotation required by the workcenter supervisor, etc. Planned changes allow workers to schedule their personal affairs and if these changes are kept to a minimum, there should be few comments showing discontent.

Worker recognition. You should plan how to give recognition to your workers; with an award, an opportunity for advancement, or compensatory time, etc. To illustrate, your planning may include challenging workers by assigning more complex or unfamiliar tasks in an effort to permit them to show their superior ability and for you to show your appreciation and recognition of their capabilities. Or your plan could be to delegate authority so that your people can gain supervisory experience and pride in their team and the work, and so that each can learn the problems inherent in an installation and determine solutions to those problems. You must, however, accept the blame if the results of this delegation are not totally satisfactory.

Worker safety. Planning should include safety, too. You should become familiar with the applicable safety regulations for your career field and determine the best procedures to insure that the crews know and use the authorized installation methods. For example, you must be sure that all crewmembers have Air Force driver permits that you enforce the regulation that vehicle drivers and riders fasten their seat belts, and that drivers always drive defensively. Likewise, you must have a plan for seeing that your people practice safety, that you observe them at work, periodcally, and that you counsel those who are careless. You should incorporate into your training an approved safety task or program for your team.

Supervisor coordination. Planning also involves your immediate supervisor and possibly associate supervisors.

Since your immediate supervisor will influence your decisions, keep him or her knowledgeable of job situations, coordinate your plans, and seek advice on problems with which you have difficulty. Be sure that you have all the facts, plan so that they are organized logically, and determine probable recommendations for solutions to the problems. Your planning may require coordination with supervisors outside your organization to eliminate delays in supplies, to reduce or eliminate interruptions during the work period, and to insure that preliminary and cooperative activities are complete when your team is ready. To illustrate, consult with outside plant supervisors to insure that they have cables installed and ready for your drop wire termination. Likewise, the base installation engineers should have the building complete and the power connected, and the using organization should have the furniture in place when you are ready to install the telephone equipment.

Exercise (402):

1. Match the planning statement in column A with the manning factor of column B. Each factor will be used twice.

Column A *Planning*	*Column B* *Manning Factor*
____ (1) Drive defensively.	a. Worker assignment.
____ (2) Reduce supply delays.	b. Worker recognition.
____ (3) Delegate authority wisely.	c. Worker safety.
____ (4) Schedule on-the-job training.	d. Supervisor coordination.
____ (5) Job limitations.	
____ (6) Job advancement challenge.	
____ (7) Equipment belt use and care.	
____ (8) Insure cables and furniture are in-place.	

1-3. Materiel Planning

Supply management is one of the your responsibilities as a supervisor. You must take note of the bench stock and applicable records and observe your team's procedures closely to be aware of how they are using spare parts. Likewise, when planning an installation, you must also consider the materiel requirements for the job.

403. Cite supervisor tasks for supply management.

Materiel Management. Your planning must include a schedule for inspecting bench stock for adequacy and for ordering those devices in low supply and needed devices new to the inventory. Study the spare parts lists that accompany the telephone equipment to be installed, applicable technical orders for the equipment, supply publications, and the budget for your organization in preparing your plan. Through budget study you will know what is authorized and how much has been used. Remember, your good judgment (based upon experience) will limit the stocking of seldom used items.

Exercises (403):

Each of the following statements relates to management. Place a T before each statement if it is truly materiel management related and an F before it if it is another type management.

____ 1. Ninety-day review of file and bins.
____ 2. Evaluate worker quality.
____ 3. Be familiar with Government property reports.
____ 4. OJT record documentation.
____ 5. Note the lamps authorized and on-hand
____ 6. Request Air Force driver permit testing.
____ 7. Budget cycle submission requirements.
____ 8. Review TOs and AFRs on-hand.

404. Define bench stock and state supervisory tasks for care of it.

Bench stock. Bench-stock is an inventory of spare parts that can't be locally repaired. As supervisor, you must review the bench stock records and look at the usage of equipment spare parts. Bench stocks are based upon this consumption data. Refer to stock records and the spare parts lists that accompany equipment. The records will show the parts that are used most often.

Use the prescribed supply form to order the parts that you think are necessary bench stock. If you are establishing a new quantity, also show justification information on the form.

Review the master file weekly. Order spare parts at least once a month. Look through the file and the bench stock bins every 3 months to determine if there is a need for changing your requirements.

Exercises (404):

1. Define bench stock.

2. Name three bench-stock reviews you must make.

3. What is a requirement when making a new bin request?

405. Cite outside wire run supervisory tasks and list required outside wire run installation materiel.

Having the authorized people and having them assigned to crews is not the end of your responsibility during an installation project. You must also have the necessary materiels available to the crew.

Outside wire run. In order to determine exactly what materiel is needed, you must go to the station area and inspect and talk with the users. If your planning is good, you use the proper specifications, you order and receive quality equipment, and the installation is done correctly, the installed telephone system should last indefinitely.

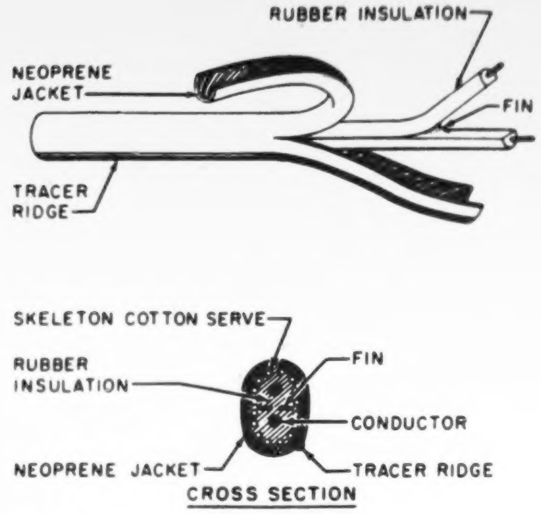


Figure 1-4. Parallel drop wire, jacketed.

AFR 66-1, *Maintenance Management*, Volume 5, states that you submit a recommended list of equipment to materiel control. This function, in turn, reviews the list and coordinates with supplies management to get the materiel you request. Sample equipment which you will be ordering for an installation includes: Instruments by type, telephone cords, 66-type terminals, running cable, drop wire, connecting blocks, and hardware, such as clamps, staples, bolts, screws, split knobs, drive hooks, brackets, etc. Of course, some equipment will be on hand. Since it takes time for equipment to be supplied, plan your project so that supplies management will have adequate lead-time to procure your needed equipment.

You must make sure that your plan includes the proper tools, wire, building attachments, and anchoring devices necessary to complete the installation. Plan to use regular installer tools to install the drop and block wire plus additional special tools which you may sometimes require. The materiels, however, may vary from job to job. In selecting wire for outside runs, you normally have three types to choose from: parallel drop, twisted pair block, and twisted pair bridle. Choose the type of wire best designed to do the job.

Exercise (405):

1. List four typical tasks for a telephone installation supervisor.

2. Name publications with which a supervisor should be familiar.

3. List four outside run installation materiels you will need at a building.

406. For given outside wire run materiels, name distinguishing factors for each.

To plan an installation you must know the purpose and advantages of the wire available. Hence, we'll consider parallel drop, twisted pair block, and twisted pair bridle wires as examples of the information you should note when planning a job.

Use parallel drop wire primarily in span runs. We mean by this statement that it is the portion of the aerial wire that extends from the open wire or cable terminal-can to the first building attachment. Two types of drop wire are illustrated in figures 1-4 and 1-5. The jacketed parallel drop wire shown in figure 1-4 is one type used in Air Force installations. You may find the dumbbell type shown in figure 1-5 already installed at many established bases. In figure 1-4, the tracer ridge on the neoprene jacket always identifies the ring wire. The cotton serve adds strength to the drop wire. The fin between the two insulated conductors prevents them from shifting within the jacket, yet makes it easier to separate the individual wires. You can also use parallel drop wire on building runs to avoid the necessity for splicing. For economy and ease of handling, however, twisted pair block wire is preferred for use on building runs (the portion of the drop or block wire extending between the first building attachment and the station protector). Also use twisted pair block wire as an inside duct wire where extreme moisture is present. It is not normally used in span runs, and only in the building-to-building spans if the length is less than 35 feet.

Use twisted pair bridle wire for connecting open wire circuits to pole-mounted drop wire and cable terminals. Do not use it, however, in span or building runs. Twisted pair block wire and twisted pair bridle wire are illustrated in figures 1-6 and 1-7 respectively. The difference between the two is not readily noticeable. The conductor in the twisted

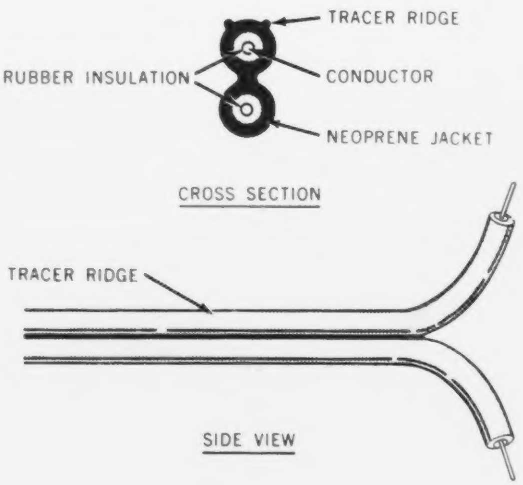


Figure 1-5. Parallel drop wire, dumbbell.

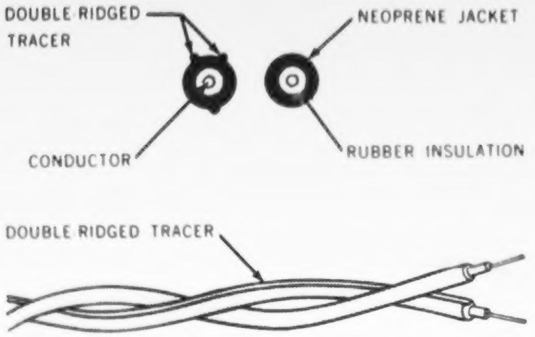


Figure 1-6. Twisted pair, block wire.

pair block wire is No. 20 gage (0.0319-inch) copper, copper-steel, or bronze, whereas the conductor in the twisted pair bridle wire is No. 14 gage (0.0640-inch) annealed copper. Twenty-gage block wire is used for the normal subscriber telephone lines, whereas the 14-gage bridle wire is used for toll line and teletype circuits.

There are various types and kinds of building attachments and anchoring devices for supporting drop and block wire runs. Just as with wire, these attachments are designed for specific uses. When selecting attachments consider the following conditions:

a. The number of wires to be supported.

b. The building surface (frame, brick, masonry) on which the wires are to be installed.

c. The storm loading district (the load placed upon a pole line by the wind and ice in combination with the weight of the line components.)

d. Whether the installation is exposed or unexposed.

You must also consider The protection requirement for a station when planning the installation. Station protectors may be either fused or fuseless. The design will vary depending on the manufacturer and the requirement. The fused type is generally used in connection with aerial drop and block wire. Only the fuseless type at stations served directly from grounded sheath cable. The three sizes of ground wire are number 6, 12, and 14 AWG, rubber or plastic insulated. Use the number 6 ground wire for pole-mounted equipment and number 12 or 14 wire with station protectors. Use the strand ground clamp to attach ground wire to a cable suspension strand and the adjustable strap clamp to attach the wire to pipe, rods, or conduit. Conduit is either concealed or unconcealed.

Exercise (406):

1. Place the letter for the distinguishing factor statement of column B in the blank before the outside wire run materiel of column A to which it relates. Each letter can be used only once.

Column A
Materiel

____ (1) Parallel drop wire.
____ (2) Dumbbell drop wire.
____ (3) Twisted pair bridle wire.
____ (4) Twisted pair block wire.
____ (5) Building attachments.
____ (6) Fused station protector.
____ (7) Fuseless station protector.
____ (8) Ground wire.
____ (9) Ground clamps.
____ (10) Conduit.

Column B
Distinguishing Factor

a. .0640-inch annealed copper.
b. Concealed or unconcealed.
c. 6, 12, and 14 AWG, rubber or plastic insulation.
d. Primarily used in span runs.
e. Preferred on building runs.
f. Interconnects ground wire and telephone system equipment.
g. Not used with new installations.
h. Selection based on wires, building surface, and district load factor.
i. Serves stations having grounded sheath cable.
j. Serves stations connected to aerial cable.

407. Identify factors and materiels to consider when planning an inside wire run.

Inside Wire Run. The materiels and equipment needed for placing inside (station) wiring are usually determined by the wiring facilities already available. Many large, modern buildings are constructed with conduit systems that carry the inside wiring. In planning an installation of this type, obtain a drawing of the conduit system. The drawing should indicate the type of conduit, the duct routing or runs, and the location of the outlets. For buildings without existing wiring systems you must, of course, plan the inside wiring system and determine the required materiels.

Three types of wire are generally used for station wiring: plastic-jacketed station wire, block wire, and cross-connecting wire. Use plastic-jacketed station wire for all station wiring except when the runs are close to heating ducts, furnaces, or other locations where temperatures might exceed 212°. Also, do not use plastic-jacketed wire where there is exposure to extreme moisture. Use block wire where the wire will be exposed to either extreme heat or moisture or where the wiring extends outside the building to outdoor telephone sets or extension ringers.

The type ringer to use depends on the need, location, and what's available. One type is the 687 ringer box. Select the connecting block(s) to be used by determining if you are to terminate line and station wires only or if station wires are to be bridged also. A 42A connecting block is usable for both purposes. If the run is in a warehouse or similar area, plan to use insulated staples, drive rings, or universal insulators equipped with bridle rings. When using rings, install one every 4 feet. Your planning may likewise reveal a need for rubber overfloor duct. Of course, in order to determine

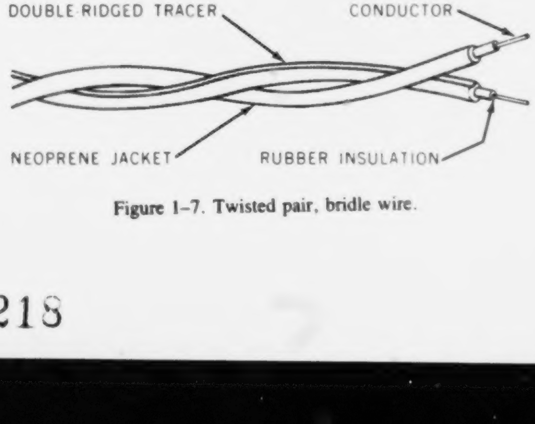


Figure 1-7. Twisted pair, bridle wire.

exactly what materiel is needed, you must inspect the station area and talk with the users.

We have only introduced you to telephone system materiel planning. Further study, consultation, and working with experienced supervisors will reveal additional factors that are involved.

Exercises (407):

1. Give factors to consider when deciding inside wiring requirements.

2. List materiel that may be required when installing an inside wire run.

408. Distinguish between C-E scheme terms and C-E management duties.

You may have been on a job where you wondered who determined the requirements and requisitioned the equipment. We will look briefly at this type of management.

C-E Scheme Management. A C-E scheme is an Air Force plan for installing a communications system. Although the installation is beyond the capability of the local communications workcenter, a local C-E officer determines the requirements.

Requirements. The requirements are determined by studying guidelines and coordinating with local authorities. Typical requirements are:

- Operation concept (exclusion, priority needed, type of security, etc.)
- Type of information or data to be received and transmitted.
- Level of reliability required.
- Relationship with existing C-E facilities.
- All other known factors that might influence the acquisition and facility's operation.

The C-E requirement may be standard or nonstandard. It is standard if the needed equipment is already in the Air Force inventory or is Air Force approved-commercial equipment. Thus, it exceeds or equals the performance standards and includes adequate equipment to support the needs reliably. The nonstandard requirement term implies that new equipment must be designed and developed. The Air Force Logistics Command (AFLC) assists commands in determining whether the equipment is standard or nonstandard. A nonstandard requirement requisition must be submitted to HQ USAF for validation. A standard requirement request also includes a CEIP (communications-electronics implementation plan).

A CEIP has all the implementation details. It has the specific requirements for hardware, construction, money, and manpower. Major commands use the CEIP to get USAF Headquarters approval, and AFLC uses the approved plan for getting the equipment and maintaining it. Since it is the operation evaluation and system analysis program plan, it must be thorough and coordinated with all activities involved with the system.

Equipment requisition. In years past, whatever was requested was delivered. In some cases, then, complete sets of equipment were received when the only thing needed was an individual item of the unit. Today, standard facility equipment lists describe each facility functionally and itemize each unit required for the system. Thus, the planner should order only what is actually needed.

For you to understand fully the C-E management program for determining requirements and requisitioning equipment, we recommend that you study the appropriate regulation when preparing to assist in monitoring a C-E scheme.

Exercises (408):

In this listing of words, show the C-E scheme terms by placing a T in the blank and a management duty with a D. One may have both entries.

____ 1. Standard.

____ 2. Communications-electronics implementation plan.

____ 3. Study.

____ 4. Requirement.

____ 5. Requisition.

____ 6. Nonstandard.

____ 7. Coordinate.

1-4. Installation Planning

As an installer-leader you should plan the installation of substations very carefully. If you follow a planned procedure while working, you can avoid a great deal of confusion, many headaches, and much expense. Planning may be defined as the act of prearranging details.

Good planning results when such factors as job quality, time, and expense are considered. Determining in advance the steps required for solving a particular problem or doing a job is not a difficult undertaking. The trouble we get into is generally caused by faulty, incomplete, or nonexistent plans. All plans have some merit.

409. Cite telephone installation planning steps and factors to be considered.

Installation Planning Steps. The steps you'll use here compare to the work procedures you have already studied in the preliminary volumes. To illustrate, you'll study documentation, talk and coordinate with others, and inspect and test equipment.

Steps. Your first step in planning for an installation is to get the information which is on the local communications service order. From the service order, you can obtain such information as the type of service requested, the location of the installation, and the number of the pair which has been assigned for the installation. After this information has been obtained, test the assigned pair or circuit with the test board. You should go out and talk with the subscriber to determine the desired location of the subset(s) and if there are any unusual activities that would affect the installation. It is also important to look for conditions that may affect the completed installation at a later date, such as the use of cranes or booms within the area, planned building expansion, and temporary buildings or partitions.

After obtaining the basic information you are ready to plan the routes for the outside and inside wire runs and the approximate location of the building entrance hole. To be effective, your plan must take into consideration such factors as wire clearances, protection requirements, the equipment and tools needed, and job control.

Exercises (409):

Arrange the planning steps below in proper sequence by placing a number in the blank before each statement.

____ 1. Test the pair.

____ 2. Determine type of service.

____ 3. Inspect the area.

____ 4. Get the local communications service order.

____ 5. Talk to user.

____ 6. Look for unusual circumstances at requested location.

410. Define telephone wire clearance as used in installation planning.

We noted above that your telephone installation planning must consider wire clearance, protection requirements, etc.

Wire Clearance. Clearance specifications for outside wire runs consist of the vertical distance between the ground level and the lowest point in the wire span, and the separation between the telephone wiring and existing objects or other services. To illustrate, drop wires must be at least 3 inches from a pole climbing step. Inside wire runs also require specific separation from foreign obstacles unless certain mechanical protection is used. The Air Force has accepted the various wire clearance specifications established by the National Electric Code. You must comply with them to insure safe, trouble-free installations. Required clearances that affect an installation are contained in Air Force approved publications. Consult these publications whenever a clearance specification is required.

Exercises (410):

1. Define clearance as it pertains to telephone wire sag.

2. Define clearance as it pertains to telephone and power wires.

411. Cite additional planning considerations and specify differences in drop wire installations.

Appearance and Safety. The outside installation, which normally includes the drop wire and the necessary attachment hardware, must combine a good appearance with safety; that is, the installation must not endanger people or property. Safety is of prime importance when placing drop wire near other wires or points from which the clearance is specified.

In planning the drop wire run, you must consider its appearance and decide whether or not the installation might cause accidents. For example, the drop should not run over areas where future building work is expected, and it should be kept away from window fronts. If the wire will pass too close to existing objects or through tree branches, plan a route for the wire which will provide the proper clearance. This may be done as illustrated in figures 1-8, 1-9, and 1-10.

In figure 1-8, the installer avoided a tree by considering the location of the first building attachment. In figure 1-9, a tree has been avoided by attaching the drop to an adjacent building. Furthermore, in figure 1-10, a tree has been avoided by using a span clamp to attach the drop wire to the aerial cable. In planning an installation, you must use many alternatives, such as those illustrated in these figures, to provide the proper wire clearance.

When the drop wire must pass under the sloping part of a roof, plan on placing the first attachment (the first fastening of the wire to the building) as near the eaves as possible. Also make sure that this attachment will avoid making a swinging

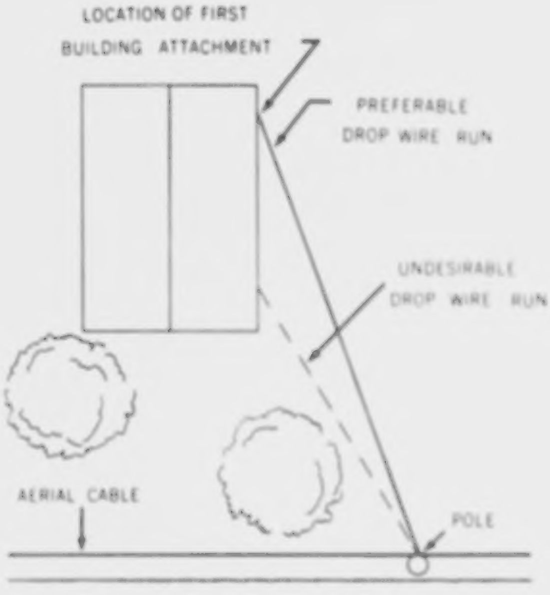

LOCATION OF FIRST
BUILDING ATTACHMENT
PREFERABLE
DROP WIRE RUN
UNDESIRABLE
DROP WIRE RUN
AERIAL CABLE
POLE

Figure 1-8. Avoiding tree by selection of building attachment.

contact between the telephone wire and any electrical service or radio wiring. The appearance of the drop wire on the building and the requirement for saving materiel dictate that the wire run should be made according to standard practices.

Exercises (411):

1. What is the consideration most evident in the installation of figure 1-8?

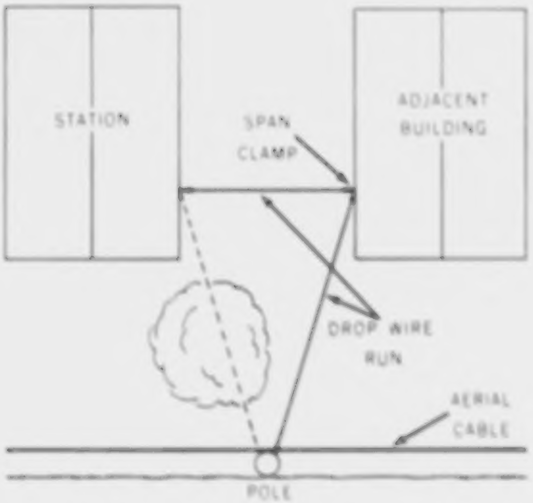

STATION
SPAN
CLAMP
ADJACENT
BUILDING
DROP WIRE
RUN
AERIAL
CABLE
POLE

Figure 1-9. Avoiding tree by use of span clamp.

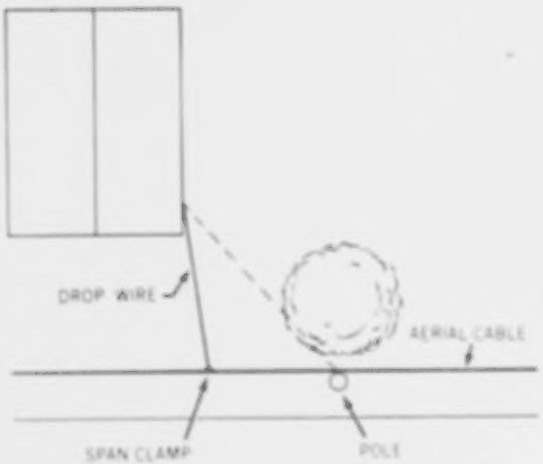

DROP WIRE
AERIAL CABLE
SPAN CLAMP
POLE

Figure 1-10. Avoiding tree by use of additional attachment.

2. Name the planning factor not mentioned in exercise 411-1.

3. What did the plan for the drop wire run of figure 1-9 call for?

4. Compare the installation arrangement of text figure 1-10 to that of figure 1-8.

412. Specify two factors that telephone station protectors shield against, name their types, and give four of the five installation requirements.

Protection. As a general rule, protectors are used with all installations connected to aerial plant facilities. The station protector shields the station apparatus (telephone sets and auxiliary equipment) against abnormal surges of current and voltages from power lines and lightning. Long aerial telephone circuits are particularly subject to these abnormal surges. If protectors are not used on exposed telephone circuits, the equipment may be damaged and persons using the equipment may be injured.

NOTE: A drop or block wire is considered to be exposed under the following conditions: (1) when the wire crosses or parallels power lines operating at 300 or more volts, (2) when the wire connects or bridges to an open wire circuit, and (3) when the wire connects or bridges to an exposed cable. Underground cables which have no connection to aerial wiring are so well shielded that lightning has practically no effect on them.

Protectors may be indoor and outdoor. In both types, all devices are attached and the unit is ready for use. Figure 1-11 illustrates a typical indoor protector, and figure 1-12 shows a typical outdoor type. It is evident that the devices in the outdoor protector are protected from the weather by a housing. Each of these are fused protectors. Figure 1-13 shows a fuseless type which you install in a circuit that has power contacts that make. The operated protector removes the equipment from the line. Although we are not illustrating the high voltage protector which shields against 3,000 volts, the protector indoor terminals, or the fuseless connecting blocks which remove the need for fused indoor protectors, you may also need to consider them in your planning.

Install the station protector where it (1) is close to the ground wire and to the building entrance hole, (2) is separated from power wires and utility meter and accessories by at least 1 foot, (3) is not more than 5 feet above the ground at an outside location, (4) is not apt to be damaged, and (5) can be inspected and maintained quickly and easily.

Exercises (412):

1. A protector shields the station apparatus against what factor caused by lightning?

2. Identify five types of protectors.

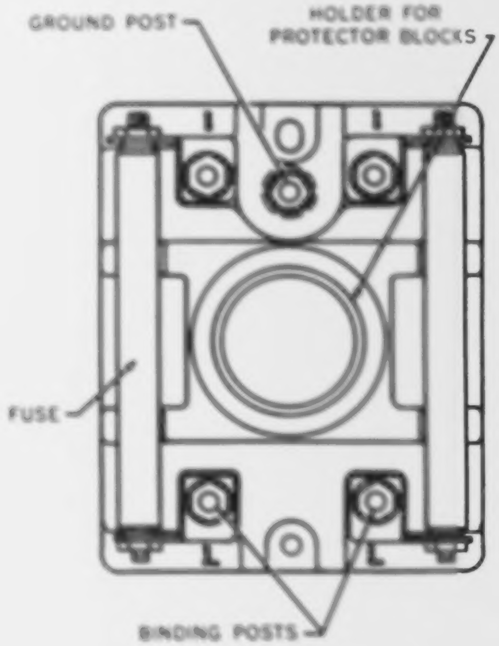


Figure 1-11. Typical station protector, fused type

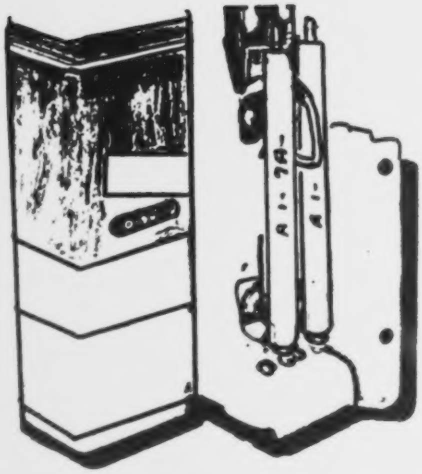


Figure 1-12. Typical outdoor type protector.

3. Give the separation requirement for a telephone system protector and a utility meter.

4. Give the maximum height for a protector.

5. Give two additional safety procedures to consider when installing a protector.

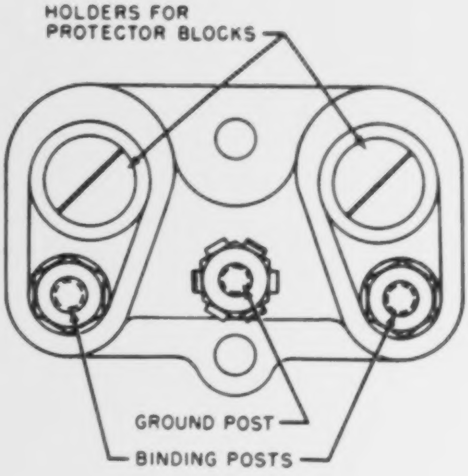


Figure 1-13. Typical fuseless station protector.

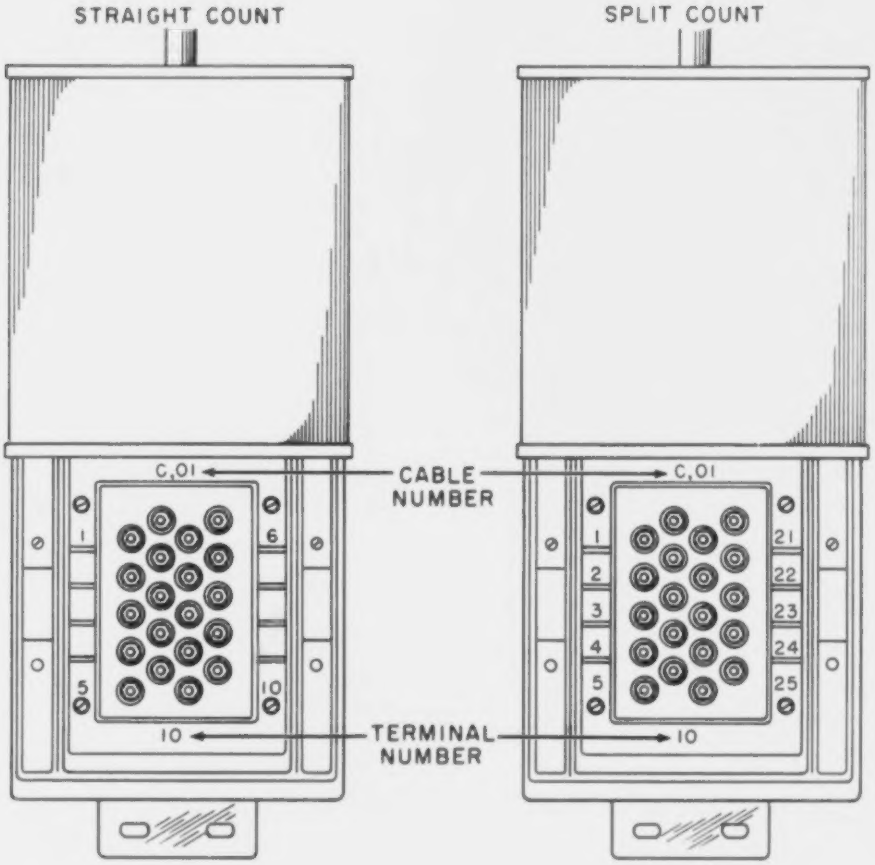


Figure 1-14. Typical pole mounted terminal.

413. List types of installation equipment.

Equipment. Good equipment and tools are essential when you are installing and maintaining a telephone system. You will use test equipment to insure the quality of connections and operation of the equipment. We noted such test equipment in Volume 2. As a team leader, you must insure that the team has the needed test equipment on the truck before they depart the workcenter. Further, you must request the required telephone plant equipment that is to be installed, follow up to see that it is provided, and see that it is on the truck before departure.

Examples of installation equipment illustrated and briefly mentioned below are: pole mounted and pedestal mounted terminals, telephone, ringer box, lineman's body belt, and climbers.

a. Pole Mounted Terminal. The pole mounted terminal illustrated in figure 1-14 is a distribution type because it has only one grouping of terminals. A unit having two such groupings is named a cross-connect pole mounted terminal. The distribution terminal grouping may consist of varying numbers of binding posts or terminals; for instance, 26 and 51 terminals are common arrangements. Since the unit is to be installed outdoors, the binding posts are within a housing which shields them from the elements.

b. Pedestal Mounted Terminal. The pedestal of figure 1-15 consists of a backplate, lower cover section, and upper cover section. The lower section and the associated back plate area are buried at least 10 inches to protect the exiting cables as they are brought up to the terminals in the upper section. Note, too, that there is a removable protective cover for the upper section.

c. Telephone. Figure 1-16. illustrates a telephone which has the same components as the 500 telephone, and is operated and serviced in the same manner. Of course, they differ in installation since this one is placed on a wall whereas the 500 is placed on a deck or table.

d. Ringer Box. The 687 ringer box is illustrated in figure 1-17. The ringer shells, coil, wiring, and terminals are most evident in this picture. To the right is the cover you place over the equipment after having connected the wiring to the terminals.

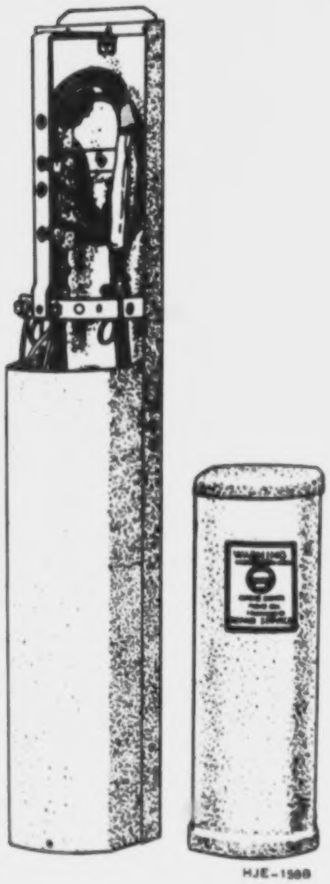


Figure 1-15. Typical pedestal mounted terminal.

e. Lineman's Body Belt. The belt and safety strap illustrated in figure 1-18 are made of high grade leather. Note that the safety strap is carried with the metal snaps hooked to the left side D-ring. Additional devices on the belt are the tape sling, the tool loops, knife snap, and the buckle. Safety straps are adjustable to 60- through 90-inch lengths.

f. Lineman's Climbers. The climbers illustrated in figure 1-19 are steel and include the leather ankle strap, leather leg strap, and the gaff. They range in length from 13 inches to 20 inches.

Exercises (413):

1. What are two types of equipment the leader should plan for?

2. What is the difference between a distribution-type pole mounted terminal and a cross-connect pole mounted terminal?

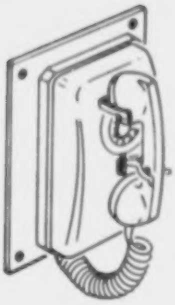


Figure 1-16. Example wall telephone.

3. List two pieces of equipment often worn by an installer.

414. Cite important team leader tasks for tools and specify tools to use for installation steps listed.

Tools. Relatively few tools are required by the installer. Proper tools make your job easier and provide better quality installations. Without the proper tools (and the knowledge of how to use them) you and your crew waste time and take the risk of inuury because of it.

The proper selection and use of tools is a part of every installation or repair job. In fact, learning to select and use tools in the proper manner is probably one of the most important subjects in your training. Before you can select the tools for doing a given job, you must know what tools are normally available. The tools used by the installer-specialist are covered in technical orders on telephone plant construction (TOs of the 31–10 series) and example tools are illustrated and reviewed briefly in the following paragraphs.

a.Pliers. Three types of pliers you will use as an installer-specialist are illustrated in figure 1-20. These types are the lineman's pliers, the diagonal pliers, and the long-nose pliers. The lineman's pliers are side-cutting pliers with blunt jaws, having a scored gripping surface at the front and cutting edges on the side. Use them for cutting wire for nicking solid wire for breaking, for holding wire for bending and twisting, and for crushing and stripping insulation. Use the diagonal pliers, with cutting jaws set at an angle of about 15° for cutting small wires. The long-nose pliers have long,

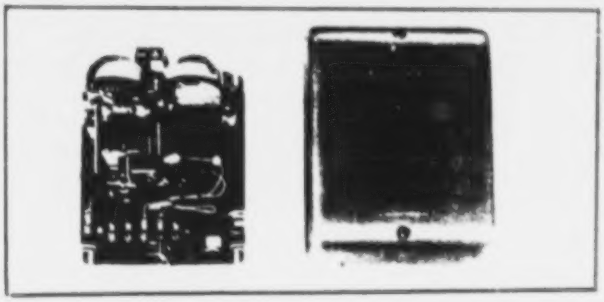


Figure 1-17. 687 ringer box.

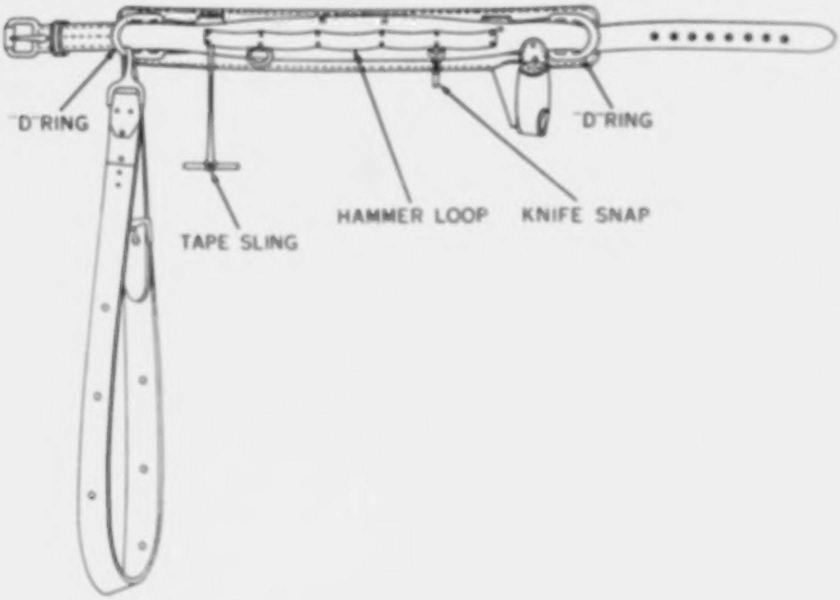

"D" RING
"D" RING
TAPE SLING
HAMMER LOOP
KNIFE SNAP

Figure 1-18. Lineman's body belt with safety strap.

slender jaws, flat on the inside with scored gripping surfaces near the tip end. Use them for holding and bending wires for attachment to terminal lugs and for gripping small objects not accessible with your fingers.

b. Hammers. Figure 1-21 illustrates a lineman's hammer and a wooden mallet. The lineman's hammer is approximately 15 inches long and has a 2-pound, double-faced head with a wooden handle. Use it for driving lag screws and thru-bolts, and on heavy line work requiring an accurate, heavy-duty hammer. Use the wooden mallet for driving and forming operations on tools or materiels which might easily be damaged by blows from a metal-faced hammer.

c. Saws. Figure 1-22 illustrates a hacksaw and a keyhole saw. Use the hacksaw to cut pieces of metal, tubing, etc. Its frame is normally adjustable to use blades from 8 to 16 inches in length. The points of the teeth on the blade should point away from the handle when the blade is properly attached to the frame. With the blade inserted in the frame in this manner, you should move the saw forward with a light, steady stroke. At the end of the stroke, relieve the pressure and draw the blade straight back, making no cut on the back stroke.

Hacksaw blades are normally provided with 14 to 32 teeth per inch. Use blades with 14 teeth per inch on heavier materiels where the coarse pitch of the teeth makes the saw free and fast cutting. The blades with the greater number of

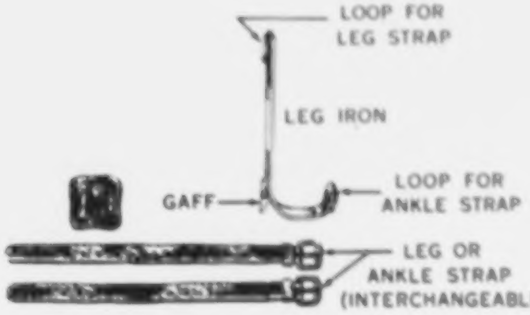

LOOP FOR
LEG STRAP
LEG IRON
GAFF
LOOP FOR
ANKLE STRAP
LEG OR
ANKLE STRAP
(INTERCHANGEABLE)

Figure 1-19. Sample lineman's climbers.

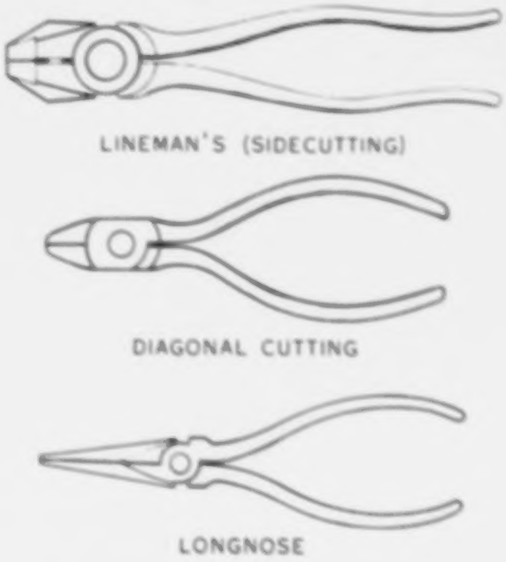

LINEMAN'S (SIDECUTTING)
DIAGONAL CUTTING
LONGNOSE

Figure 1-20. Typical pliers.

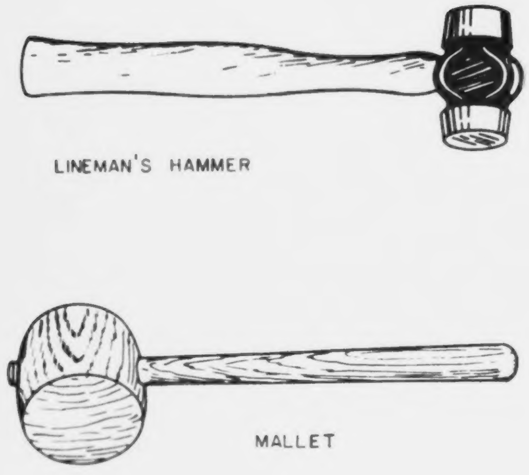


Figure 1-21. Typical hammers.

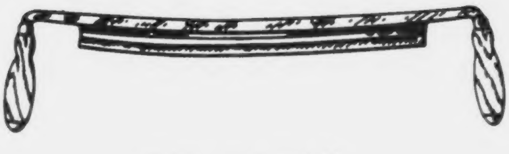


Figure 1-23. Draw knife.

teeth are used on thinner material. For example, a blade with 32 teeth per inch is used on thin-wall tubing, conduit, and sheet metal thinner than 18 gage.

Since the keyhole saw has a tapered blade, use it to cut along a curved line, and to start a cut for a larger saw.

d. Draw knife. The draw knife illustrated in figure 1-23 is a very important tool to telephone plant personnel. Use it to smooth poles, remove gaff marks, and to shave away excess wood. It has a single-bevel, knife-edged, steel blade and is approximately 1½ inches wide and 12 inches long. It has wooden handles at each end and at right angles to the blade.

e. Brace and bit. The brace and bit illustrated in figure 1-24 is representative of the drills used by the installer specialist. You will use many types of bits, up to 24-inch lengths, to drill holes in walls, floors, etc.

f. Wood chisel. The wood chisel with its blade guard is illustrated in figure 1-25. The chisel shown has a single-edged, steel, 2-inch cutting blade with a wooden handle. Use this chisel to remove chips or sections of wood in framing poles. Remove these materiels by hand pressure or by striking the end of the chisel handle with a wooden mallet.

g. Wrenches. The adjustable wrench (fig. 1-26) is a general-purpose tool used for holding or turning nuts and bolts. The lineman's wrench is an open-end wrench with two openings of different size at the ends. Use it on carriage bolts, lag screws, crossarm bolts, and 3-bolt guy clamps. A hole at the larger end is used for tightening or turning pole steps. The most important rule in using a wrench of any kind is to make certain that it is of proper size so that its jaws properly fit the nut or bolt.

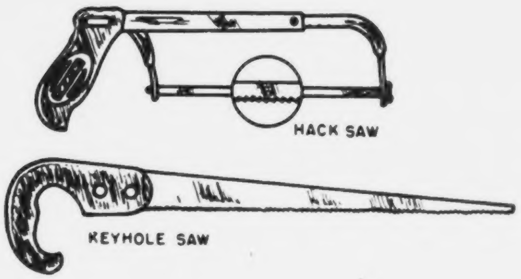


Figure 1-22. Saws.

h. Screwdrivers. The screwdriver (see fig. 1-27) consists of a blade with a tip shaped to fit in the driving slot of a screw, and a shank or tang securely fastened in a driver handle. The fixed-blade screwdriver, consisting of an integral blade and handle, is used as a general purpose tool for many kinds of screws. It is furnished in various sizes to fit the various screws.

The ratchet screwdriver, with its blade and handle, provides right- and left-hand ratchet-drive action, or rigid-drive action. The spiral ratchet screwdriver, in which drill bits and other attachments, as well as the screwdriver bits are used, is rotated by pushing on the handle, or is locked to provide rigid action. As illustrated in figure 1-27, screwdriver bits are also provided for use with the bit brace. In addition, some fixed screwdrivers are provided with a screw-holding clip, as illustrated in figure 1-27.

i. Wire wrap tool. Figure 1-28 illustrates a wire wrap gun and the tool sleeve which fits over the tool bit. Although

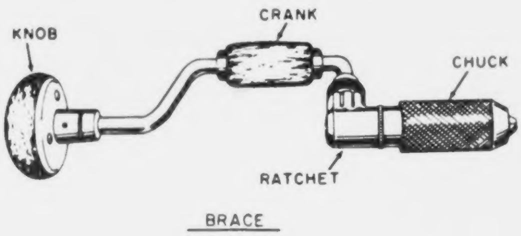


Figure 1-24. Typical brace and bit.

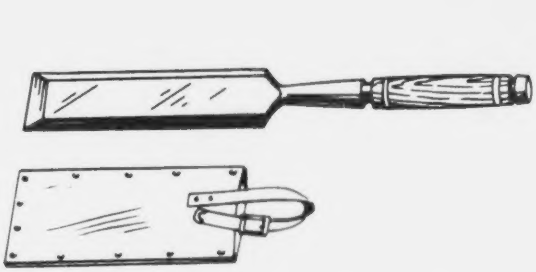


Figure 1-25. Wood chisel with blade guard.

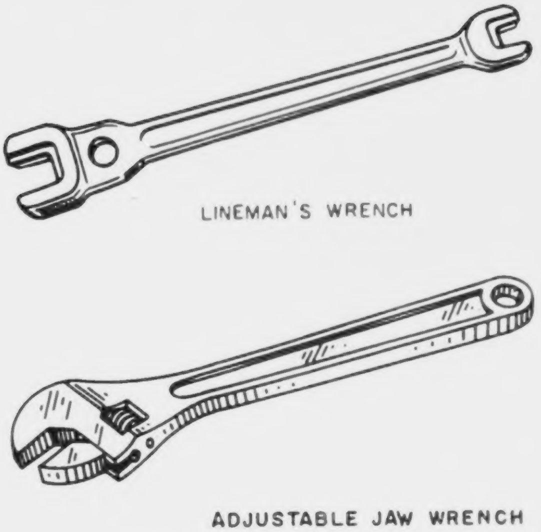

LINEMAN'S WRENCH
ADJUSTABLE JAW WRENCH

Figure 1-26. Representative wrenches.

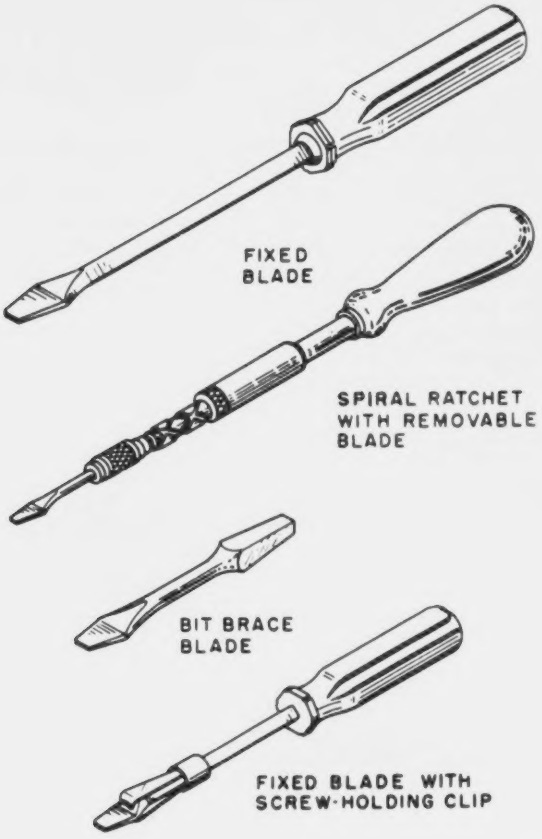

FIXED BLADE
SPIRAL RATCHET WITH REMOVABLE BLADE
BIT BRACE BLADE
FIXED BLADE WITH SCREW-HOLDING CLIP

Figure 1-27. Screwdrivers.

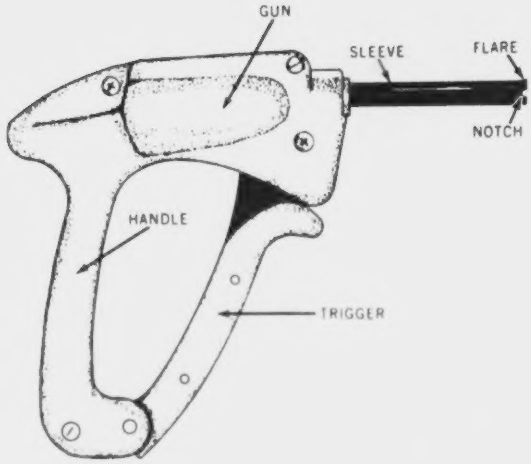

GUN
SLEEVE
FLARE
NOTCH
HANDLE
TRIGGER

Figure 1-28. Wire wrap gun.

there are several methods for powering the tools, each unit causes the bit to rotate while the sleeve remains fixed during the tool operation. Figure 1-28 also identifies the trigger for starting the wrapping operation.

Figure 1-29 is a closeup view of the ends of the tool bit and the inclosing sleeve. The axial hole (terminal hole) is large enough to permit the tool bit to be placed over the terminal of the component. Directly above the axial hole of the bit, notice the slot with its flare. The wire to be wirewrapped is inserted into this slot, and the flare in the slot allows you to insert the wire into the slot more easily. Notice the notch in the sleeve of the bit. It holds the wire in place while it is being wrapped. Figure 1-30 pictures the bit again. This time it shows a terminal and wire inserted. With the wire inserted as shown, the trigger of the wire wrap gun is squeezed to rotate the bit which wraps the wire around the terminal.

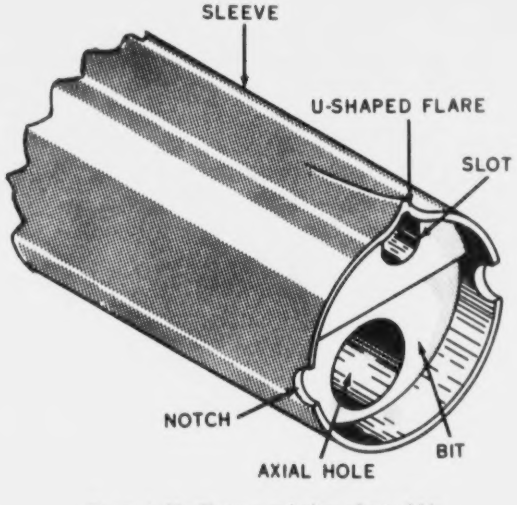

SLEEVE
U-SHAPED FLARE
SLOT
NOTCH
BIT
AXIAL HOLE

Figure 1-29. Closeup end view of a tool bit.

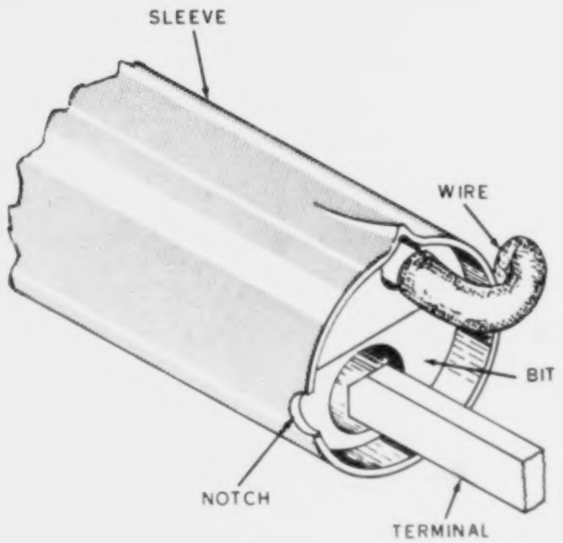


Figure 1-30. Closeup end view of wire and terminal in tool bit.

Proper tool selection and accurate loading will eliminate the problem of having to return to the workcenter several times to get another tool. Of course, the same action applies to the foregoing listed materials and equipment. Again it should be evident that you will avoid a great deal of confusion and expense by following a definite plan.

Exercises (414):

1. Give three important tasks for a team leader that pertains to tools.

2. Identify the tool with jaws used to cut small wire.

3. What tool is used to shorten conduit before installing an inside wire run?

4. Identify the tool used to smooth telephone poles.

5. Name the proper tool to use to hold and tighten crossarm bolts.

6. Cite the tool to use when attaching a wire to a terminal without using solder and a hot iron.

415. Mention four team control methods to plan for when preparing to lead telephone installers on a project.

Job Control. One job control method is the assignment of priorities to job procedures.

Assign priorities. Identifying priorities insures that the preliminary tasks are completed first. In other words, you must plan the work procedure sequence and the distribution of your workers before you leave the workcenter.

Develop timetable. You should establish a timetable for the job and for each sequence in the job. To do this, you should recognize that your past experience and the experiences of other teams have produced job time standards to use as a planning guide. Plan, too, to insure that these standards are met by constant observation, with specific directives given in an encouraging, friendly way, and with sound decisions for overcoming delays (preconceived as probable).

Plan instructions. Plan your instructions so that they are clear, positive, and understood by all team members. Consider probable objections that may be given to your directives, and determine reasons for using your method over some other method. Suggested factors to use when determining your reasons are:

- Review the task and determine alternate procedures.
- Identify all advantages and disadvantages of each method.
- Sort and analyze these facts.

Also, study the request and project requirements so that you don't ask for something to be done which is impossible to do. If you assign an installer an impossible task, you, in turn, may lose his or her respect and thus, have less control of that person.

Assign workers. Plan worker assignments to prevent injuries and delays. To illustrate, the assignment of many workers to one work area could result in people having to stop working temporarily so that others can do a related task or can walk around or through that work area. The subsequent task to be performed may be of the type that could injure the second worker. For example, soldering a terminal at a higher level could cause molten solder to drop on a worker at a lower level. Of course, every pause results in a job delay. Plan each project so that there is a minimum of duplication of effort.

Stress work safety. Plan a work-safety briefing to be given to your team either before departing for the job or before beginning the installation, whichever is most applicable for the specific project. Plan to appoint a worker to inspect the tools and equipment and to observe the work procedures of the team members during the times when you are not available or are not in position to see the work being done. This action should help to eliminate unsafe conditions and improper procedures when you are away.

Review plan. After you've completed the preliminary planning for the project, recheck to be sure that each part of your plan is still correct and that all parts fit together. It may be necessary to make changes or revisions, such as changing the proposed wire run because of an error in your measurement of the clearance and separation requirement or specification, or the illness or other emergency of a team members. Remember, a little more time spent in planning usually results in fewer problems and in less time at the installation site.

Exercises (415):

1. What control method are you using when you program installation of the key system power cable first before installing the running cable?

2. State a common use for the following specification: Inspect the housing and dial face of 10 telephones per hour and wipe each clean.

3. Give two job control methods used by a leader while on the job.

4. Name two team leader planning tactics useful in stressing the need for safety.

CHAPTER 2

Installation Work Practices

TO BE AN EFFICIENT installer, you must know the basic tasks and procedures and be able to do each accurately within a minimum of time. Although you will be tasked to complete and use records in addition to installing and maintaining telephone equipment, we are not covering forms and record maintenance in this chapter because record requirements may vary in the different organizations. It will be up to you to learn your organization's forms and procedures.

In this chapter, we will briefly describe splicing equipment and splicing procedures; typical soldering equipment, requirements, and fundamentals; and pole climbing equipment and climbing principles.

2-1. Drop Wire Splicing

Two splices approved for use when installing a telephone system are the compressed sleeve and twisted-conductor (Western Union) splices. The compressed sleeve splice is the preferred type; the twisted-conductor splice is used only when sleeves are not available.

416. Give purpose for splices and selective information about sleeves.

A splice is often required when repairing drop wires or installing ground rods. It joins two conductors together, thereby completing an electrical circuit.

Splicing Sleeves. A sleeve for splicing drop wire is the single-bore diameter type. Figure 2-1 shows the front view of such a sleeve. The brass tubing to each side of the center indentation fits over the conductor to be spliced. In the case of the single-bore diameter sleeve, both conductors to be joined are of the same diameter. An end view of the sample sleeve is also illustrated in figure 2-1. The hole shown is of the diameter that permits a specific size conductor to slip into it. Looking at table 2-1, note the size 0.032 inch to 0.025 inch (20, 21, and 22 gage) wires. (NOTE: Both the wire gage and the diameter are imprinted on each sleeve.) Also shown in the table, are the sleeve length and type of wire for which the sleeve is developed.

The two-bore diameter sleeve enables you to splice two conductors of different diameters. Thus, the hole in the tubing to one side of the center indentation is of one size while the hole for the tubing at the other side is of a different size. For example, the table shows that the 1-inch long, two-bore diameter sleeve has a hole at one end that accepts a conductor of .045 inch diameter whereas the hole at the other end allows insertion of a conductor that is .032 inch in diameter. Use this sleeve when you connect a telephone line to a ground rod.

Exercises (416):

1. State two purposes for splicing sleeves.

2. Identify the two types of compression sleeves.

3. What size compression sleeve (single-bore type) should you use when splicing parallel drop wires?

4. Specify the compression sleeve to use when splicing parallel drop wire to twisted pair bridle wire.

417. Specify the compression sleeve to use when splicing parallel drop wire to twisted pair bridle wire.

Special tools are required to make a splice that bonds well and has continuity. We'll review briefly some typical sleeve preparation tools.

Splicing Tools. A sleeve compression tool is illustrated in figure 2-2. It is only one of those available for pressing a splicing sleeve onto the conductor ends. The illustrated tool is referred to as "large head." Close observation of the tool jaws should reveal two grooves. Use the larger groove for compressing the .045–.040 and .064 diameter splicing sleeve (see table 2-1). Use the smaller groove to press the tubing of the .032–.025 diameter splicing sleeve.

A wire stripper (illustrated in fig. 2-3) is used to remove the braid or neoprene jacket from drop wire. The enlarged head has three grooves to accommodate different size drop wires, two steel cutting disks, and a sliding guard. The three openings in the handle may be used to hold nuts and heads of bridging connectors.

The diagonal pliers, illustrated in Chapter 1, are used to cut bare wire and small diameter insulated wire.

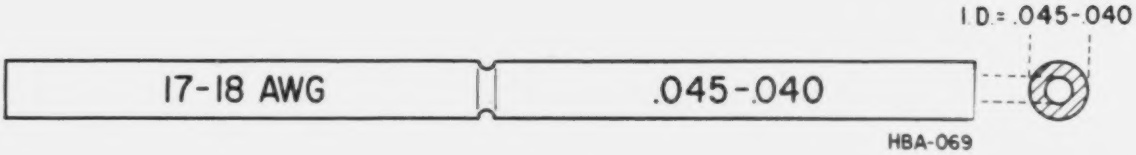


Figure 2–1. Example drop wire sleeve.

TABLE 2–1
SPLICING SLEEVE SIZE AND ASSOCIATE DROP WIRE

Size	Length (in.)	Associated Types of Wire
	SINGLE-BORE DIAMETER	
.032–.025	1	Twisted pair block
.045–.040	1⅞	Parallel drop
.064	1⅞	Twisted pair bridle
	TWO-BORE DIAMETER	
.045–.040 x .032	1	Twisted pair block and Parallel drop
.064 x .045–.040	1⅞	Parallel drop and Twisted pair bridle

CDC36254 TABLE 2–1 Volume 3

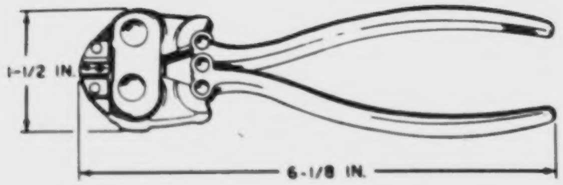


Figure 2–2. Typical sleeve compression tool.

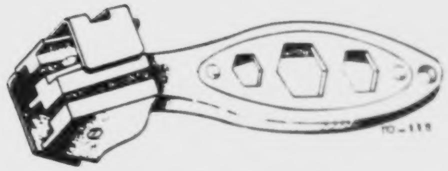


Figure 2–3. Representative wire stripper.

Exercise (417):

1. Match each of the listed splicing tools in column A with its proper function in column B. NOTE: Some of the functions listed are used more than once and some not at all.

Column A
Splicing Tools

____ (1) Sleeve compression tool.
____ (2) Wire stripper.
____ (3) Diagonal pliers.

Column B
Functions

a. For crushing and removing insulation.
b. For gripping small, hard-to-hold objects.
c. For removing rough edges.
d. For cutting bare wire.
e. For holding nuts.
f. For mating a sleeve with two conductors.

418. Specify steps required when splicing drop wires and identify two precautions to be observed.

Splicing Procedures. Figure 2-4 shows the procedure for separating the drop wire conductors after stripping off the neoprene jacket. After cutting the fin as shown in this figure, rip additional fin as shown in figure 2-5. Next, use diagonal pliers to cut the two conductors to different lengths as illustrated in figure 2-6. In this illustration, the plain conductor is approximately 6 inches long in the top detail whereas the tracer conductor is short. In the lower detail the opposite cut is shown.

With sleeves. Figure 2-6 also shows that you must remove insulation from the end of each conductor one-half the length of the splicing sleeve. Looking now at figure 2-7, you can see that the bare wire of each conductor has been inserted into a splicing sleeve. The center identation of the sleeve is the stop point for the end of the wire. The sleeve compression tool is shown around the tracer conductor and the sleeves are shown crimped where the tool has been. The sleeves are in this staggered position to eliminate the possibility of a short between each. Note also that both tracer and plain conductors are spliced together. Doing it otherwise results in a splicer error and a circuit fault.

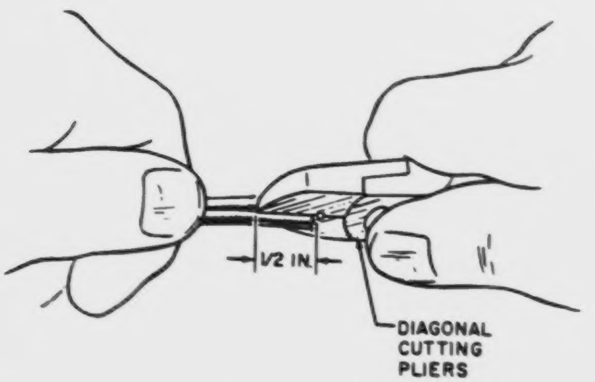


Figure 2-4. Cutting drop wire fin.

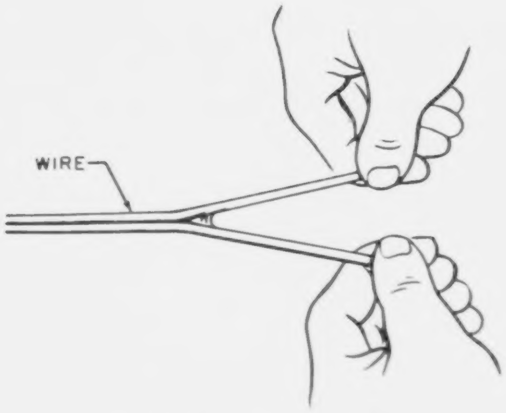


Figure 2-5. Ripping drop wire fin.

Figure 2-7 shows that there are three compressions at each side of the center indentation when the splice is completed. Following completion of the splicing as shown, you must wrap the splice with rubber tape. First wrap each individual sleeve and then cover the entire opening. The tape must extend 1 inch beyond the end and over the jacket.

Exercises (418):

1. When preparing to splice an open drop wire, what are your first two actions?

2. Describe the two splicing procedures that follow the ripping of the fin between the two conductors.

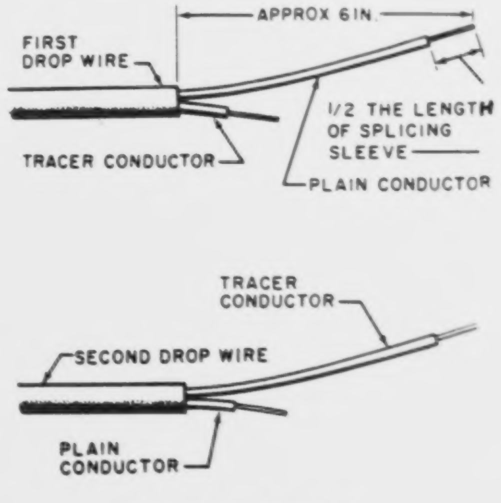


Figure 2-6. Prepared drop wires.

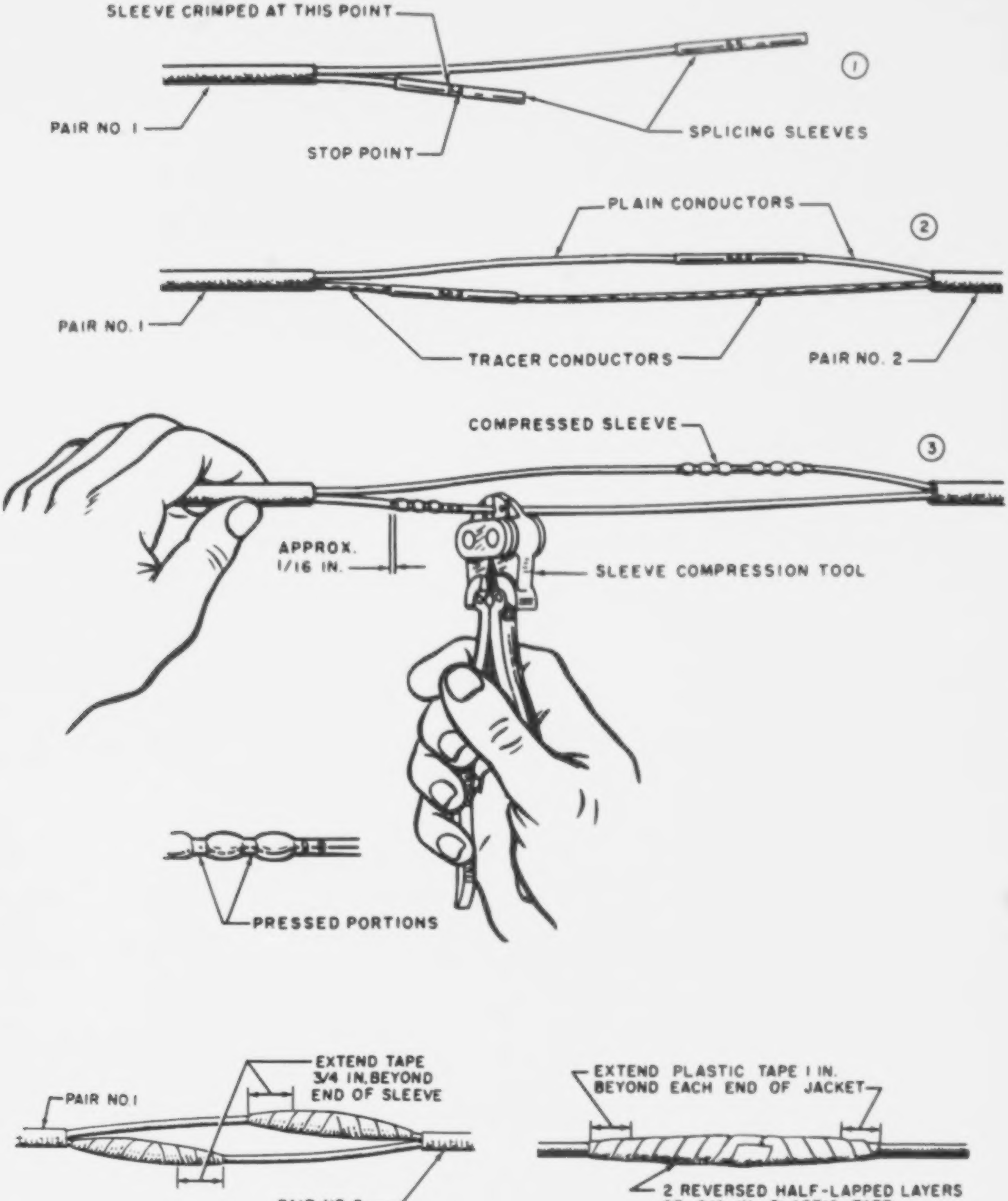

SLEEVE CRIMPED AT THIS POINT
①
PAIR NO 1
SPLICING SLEEVES
STOP POINT
PLAIN CONDUCTORS
②
PAIR NO. 1
TRACER CONDUCTORS
PAIR NO. 2
COMPRESSED SLEEVE
③
APPROX. 1/16 IN.
SLEEVE COMPRESSION TOOL
PRESSED PORTIONS
EXTEND TAPE 3/4 IN. BEYOND END OF SLEEVE
PAIR NO. 1
PAIR NO. 2
EXTEND PLASTIC TAPE 1 IN. BEYOND EACH END OF JACKET
2 REVERSED HALF-LAPPED LAYERS OF 3/4-IN. PLASTIC TAPE

Figure 2-7. Placing and crimping copper sleeves.

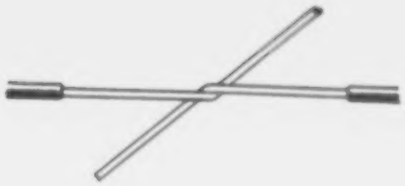


Figure 2-8. Western Union splice (first twist).

3. What splicing procedure follows the showing of the "bare wire"?

4. What is the minimum number of compressions on each installed sleeve?

5. What is the final splicing procedure?

6. State the two precautions that are required for the drop wire splice.

419. Cite steps required for making a twisted conductor splice.

Use the twisted conductor (Western Union) splice only in emergencies when sleeves are not available. Then replace it with a sleeve-type splice at the first opportunity.

Twisted conductor. Figure 2-8 shows that you first remove insulation from the two conductors to be spliced. Leave about 2 inches of bare wire for each conductor. Clean the bared wire with abrasive cloth to insure good electrical contact. Then, as shown in this illustration, cross the wire ends and twist them.

Figure 2-9 shows five tight turns at each end of the 2½ twist area. Make sure that both wires are twisted in the same manner. Cut off the remaining wire at the free ends of the tight turns (buttons). Having completed the splice as shown in figure 2-9, solder it to reduce the splice resistance and then tape it. Stagger the conductors in this type of splice in the same manner as when compression sleeves are used.

Exercise (419):

1. Listed below in mixed order are the procedures for making a twisted conductor splice. Renumber the steps in the correct order.

____ (1) Make five tight turns at each end of the twisted area.

____ (2) Apply solder to the splice.

____ (3) Cross the wire ends and twist them.

____ (4) Remove insulation from both conductors.

____ (5) Tape the splice.

____ (6) Clean the wire ends with abrasive cloth.

____ (7) Cut off excess wire.

2-2. Soldering Equipment, Requirements, and Procedures

The wiring for a telephone system must be solid and strong enough to stand for the period it is to be used. It is easy to neglect details of installation which can result in equipment failure. Splices are designed for permanent connections; therefore, make them mechanically strong and electrically perfect, or they may become a source of telephone circuit trouble. Every-installer-specialist should be able to splice and solder telephone wiring and connections.

420. Coorelate soldering terms and tools with the appropriate function.

Soldering. Soldering is the heating of a fusible alloy until it melts and incloses the contacting surfaces of two or more metals to be joined. When this combination (metals and solder) cools, it hardens to bind all the elements tightly together. When wire connections are not soldered, the oxygen in the air combines with the surface of the metal and forms a corrosion. This corrosion of connections offers additional electrical resistance to the circuit. If a connection is properly soldered, the oxygen of the air cannot combine with the surface of the metal; thus, corrosion of the connection is prevented. A soldered connection maintains good contact and, at the same time, does not loosen readily from vibration.

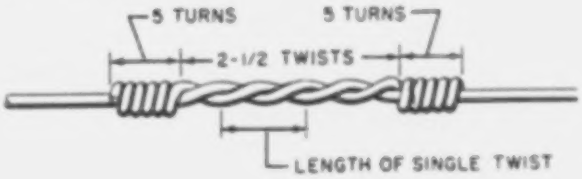


Figure 2-9. Western Union splice (final twist).

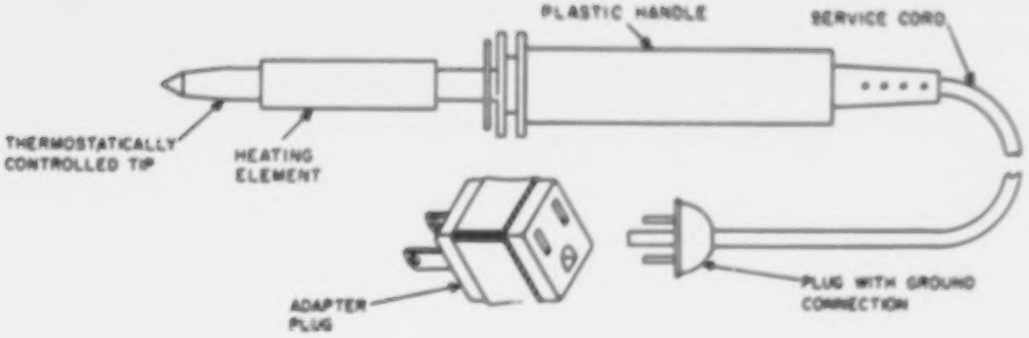


Figure 2-10. Typical electrical soldering iron (illustrated).

Soldering Equipment. The three types of soldering equipment are the electric irons and guns, chemically heated iron, and the soldering copper (externally heated copper tip iron).

Electric soldering irons. Use the electric soldering iron, illustrated in figure 2-10, for light soldering. In addition to having the normal soldering tip, shank, and handle, this iron has an electric heating element. Connect this element to an electric outlet by way of a cord and plug. One big advantage of electric soldering irons over the conventional types (units heated by torches, etc.) is that the electric iron provides a more constant tip temperature. With many electric soldering soldering irons the tip temperature is thermostatically controlled to insure a uniform soldering temperature.

Electric soldering guns. The electric soldering gun, shown in figure 2-11, is very handy for working in small, inaccessible places. It has a pistol grip and trigger switch, plus a pilot lamp which lights the area to be soldered. Most soldering guns use 115-volt, 60-cycle alternating current. The soldering gun is excellent for soldering wiring connections because of its fast heating rate. Many of these guns heat to the proper soldering temperature in 10 to 15 seconds.

Nonelectric soldering irons. Use this type of soldering iron in time of emergency when power is not available. It takes about 30 seconds for the chemically charged cartridge within the tip chamber to heat the copper tip, and the heat remains for a maximum of about 7 minutes. Releasing a firing pin at the rear of the handle activates the cartridge.

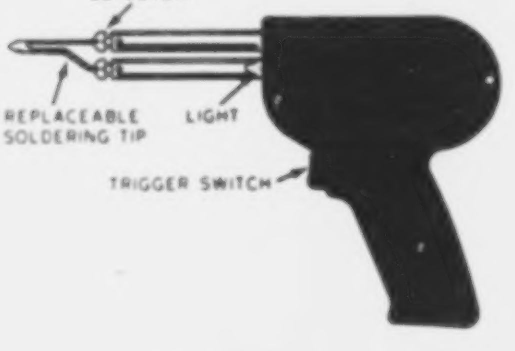


Figure 2-11. Electrical soldering gun.

Soldering coppers. Heat soldering coppers with a gasoline blowtorch, an alcohol torch, or a gas burner. Since the copper tip is not removable, you'll use different-sized coppers for the various kinds of work. The disadvantages of these devices are (1) they must be continually reheated, and (2) they frequently become overheated, causing the tip to become pitted and rough. Use this type of "iron" for the heavy soldering jobs. It is not very satisfactory for use on wiring connections.

Exercise (420):

1. Match the soldering terms of column A and the statements of Column B. Each may be used only once.

Column A *Terms*	*Column B* *Statements*
____ (1) Soldering.	a. Thermostatically controlled.
____ (2) Fusible alloy.	b. For heavy soldering jobs.
____ (3) Corrosion.	c. Binds metals together.
____ (4) Electric iron.	d. Process for sealing oxygen out of a connection.
____ (5) Constant tip temperature.	e. Provides resistance to electric current.
____ (6) Electric gun.	f. Used for light soldering.
____ (7) Chemically heated iron.	g. Most usable in inaccessible places.
____ (8) Soldering copper.	h. Heated following release of a firing pin.

421. Specify requirements for an acceptable soldered connection.

Soldering Requirements. Figure 2-12 illustrates acceptable solder connections. You should note that the good connection has the wire touching the terminal. Also, the solder coating should be light enough that the contour of the wire is visible and forms a concave fillet where the wire meets with the terminal. Further, this fillet must blend as a smooth, continuous layer from the wire to the edge of the terminal. Details B and C show that a convex formation is unacceptable, whether near the terminal or against the wire.

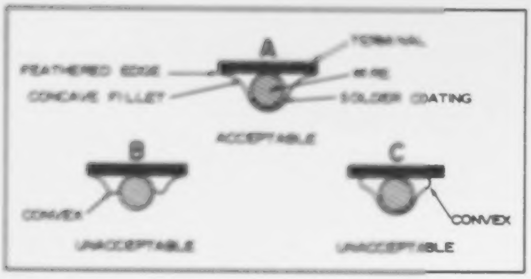


Figure 2-12. Soldered connections illustrated.

This bulge is caused either by applying too much solder or by low heat (caused by a tip surface that was not tinned properly to remove the oxides, impurities, etc.) at the junction.

Exercises (421):

1. Describe the fillet at the point where the terminal meets the wire.

2. State the requirement for solder at the terminal wire.

422. Specify procedures for making acceptable soldered connections, and describe the "flow" and "sweat" methods of soldering.

Soldering Procedures. Basically, a conductor is soldered by first cleaning and tinning the soldering iron and conductor, and then by heating the conductor, while applying solder to form the connection.

Tinning the iron. Good soldering is possible only if the tip of the iron is in good condition. Good condition means that the tip of the iron must be smooth, of proper shape, and covered with a thin coat of solder on its working surface. The cleaning and shaping of the tip along with the application of a thin coat of solder is referred to as "tinning the iron."

To clean and shape the soldering iron tip, use a medium grade file to remove the pits, old solder, and tarnished areas. To do this, heat the iron and place it in a vise or holding clamp, as shown in figure 2-13,A. With electric irons, grip only the tip of the iron to avoid damage to the heating element. If only one surface of the tip is to be tinned, file only that surface. Note that the section of the tip to be tinned is parallel to the top of the vise. When filing the tip, be careful not to cut away any more of the tip than necessary. Remove only the pits and tarnished areas, leaving a smooth, flat surface. After the filing has been done, touch the rosin-core solder to the filed side of the heated tip. The solder should flow readily over the bare area to cover it with a smooth, thin coating. Wipe off any excess solder with a damp clean cloth. Details B and C, respectively, of figure 2-13 show a properly shaped point and a poorly shaped point.

Tinning The Conductor. Clean the surface of the conductor also before applying the solder; otherwise, corrosion will take place under the layer of solder. This may cause the joint to break, or it may be a possible source of loss in voltage. A conductor is not properly tinned until it is thoroughly cleaned and then covered with a thin coat of solder. Clean it while using either wire strippers, pliers, a file, or a knife. In any case, the conductor must have a smooth, bright surface, and be free of any nicks or cuts. After it has been cleaned, cover the surface with a thin coat of solder.

The soldering process. After the iron and the materials are clean, then you'll do the soldering. In telephone work, there are two commonly used methods of applying solder: the "flow" method and the "sweat" method. When the "flow" method is used, place the tinned area of the soldering iron tip on the surface of the metal, as shown in figure 2-14. After the materials forming the joint are heated, hold the solder against the joint until it melts and flows freely. This procedure is preferred in the telephone field for most soldering work because it is faster, uses less heat, and provides tighter connections with the use of less solder.

Do the "sweat" solder method by placing the tip of the iron under the metals and the solder to the top of the metals, as shown in figure 2-15. As soon as the metals are hot enough to melt the solder, the flowing solder will surround them and make the desired bond. This latter method of soldering is preferred when splicing telephone wires.

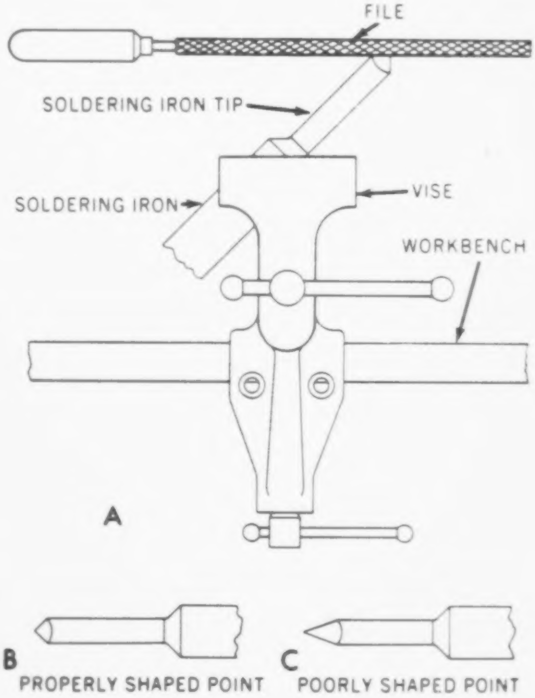


Figure 2-13. Filing the tip of a soldering iron.

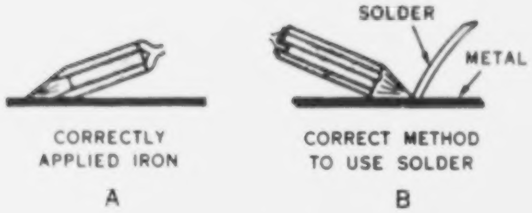


Figure 2-14. Flow method of applying solder.

With either of the soldering methods, excessive heat will cause the solder to flow away from the joint and along the conductors, and thus result in loose connections and possible short circuits. Insufficient heat to the metals leaves a large ball of solder and a weak joint. The free-flowing solder has a tarnished appearance when the heating point is correct.

After the joint has been made, remove the iron from contact with the metals gradually to prevent defects in the newly made joint. After removal of the iron, do not move the connection for a few seconds in order that it may cool and seal correctly.

Exercises (422):

1. Name the procedure to use when preparing an iron for soldering a connection.

2. Give the three actions involved in the procedure of exercise 1.

3. Name the procedure by which you prepare a to-be-terminated conductor for attachment to a terminal or to another conductor.

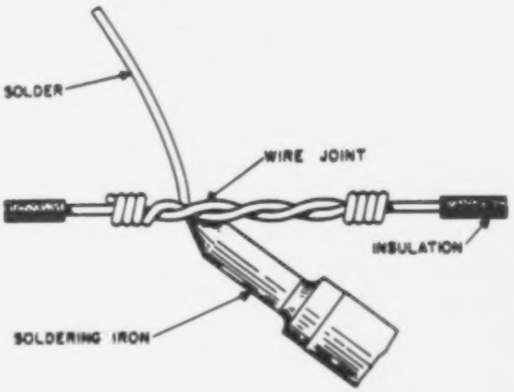


Figure 2-15. Sweat method of applying solder.

4. Describe the appearance of a tinned conductor.

5. Describe the "flow" method for soldering.

6. Describe the "sweat" method for soldering.

7. State the precaution for the final step in the soldering process.

2-3. Pole Climbing Equipment and Climbing Principles

The installation of a telephone subset may require you to climb a telephone pole. For this reason, you must have a knowledge of pole climbing and pole climbing equipment. This section describes the equipment used in pole climbing and explains some of the principles involved.

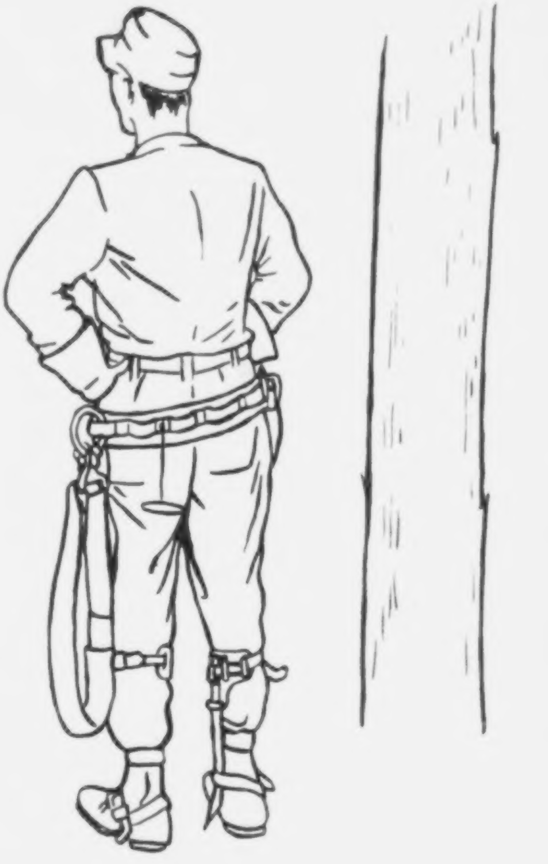


Figure 2-16. View of a specialist wearing pole climbing equipment.

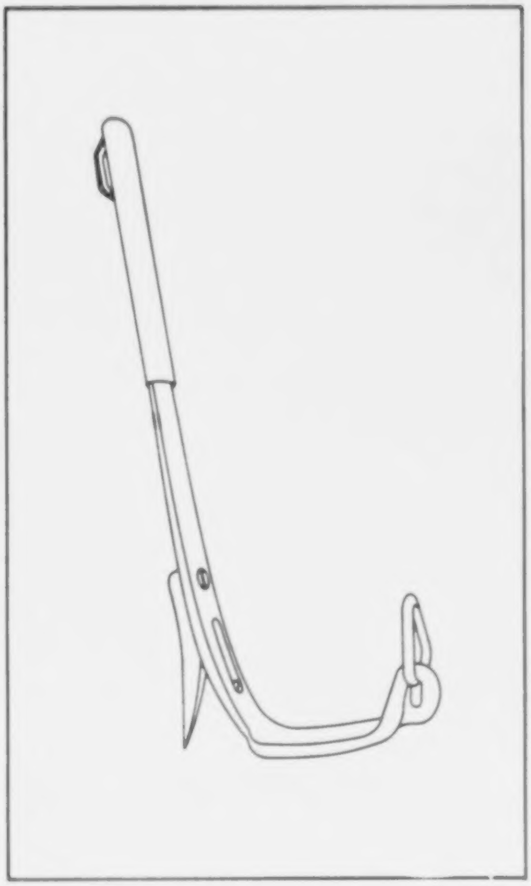


Figure 2-17. Lineman's climbers (without straps).

423. Cite fittig specifications for pole climbing equipment.

Pole Climbing Equipment. We looked briefly at pole climbing equipment in figures 1-18 and 1-19. In Chapter 1, we also noted that the climbers come in various lengths. The same condition applies to the body belt. Select your belt according to size. The actual belt measurement is the snug distance between the heels or straight ends of the two D-rings. Most supply sections provide belts which range in sizes from D–18 through D–30.

Wear the belt over your hips, tightened just enough to prevent slipping. A belt of the proper size permits the D-rings to rest just behind the projecting portions of your hip bones. Figure 2-16 illustrates the belt's position when the worker is on the ground. For safety reasons, do not punch additional holes in the body belt. If your belt does not fit properly, try one of a different size.

In the resident course and in Chapter 1, you also learned that safety straps are adjustable to various lengths, ranging from 60 through 90 inches. If you are right-handed, snap both ends of the safety strap to the left side D-ring when the strap is not in use. A left-handed person should snap both ends to the right side D-ring. Snap the end of the strap, which is doubled to permit adjustments, to the D-ring with the snaphook keeper toward the rear. Snap the riveted end of the strap onto the same ring but with the snaphook keeper facing the front. This arrangement enables you to keep the snap at the doubled end of the strap hooked at all times. Figure 2-16 pictures the hooked safety strap on the body belt of a right-handed installer.

Some climbers also are adjustable. Figure 2-17 illustrates such a climber. Adjust the upper part of the leg iron so that the distance from the arch near the gaff to the leg strap loop is 14½ inches to 21 inches. Note, too, that the climber in this illustration also has a replaceable gaff. To determine the climber length that you need, measure your leg as shown in figure 2-18. The correct length is 1/2 inch less than the distance from the arch of the foot to the small bone projecting from the lower inner side of the knee cap. A climber that is too short rubs the calf of the leg; one that is too long rides over the knob of bone on the inside of the knee. Safety during climbing is dependent on how well the gaff cuts the pole and holds the weight of your body. Hence, gaffs that are too short are unsafe. the replaceable gaff (see fig. 2-17) is easily changed and the cost of its replacement is low.

Exercises (423):

1. Give the proper size requirements for the body belt.

2. As a left-handed climber, where do you carry the safety strap when down off the pole?

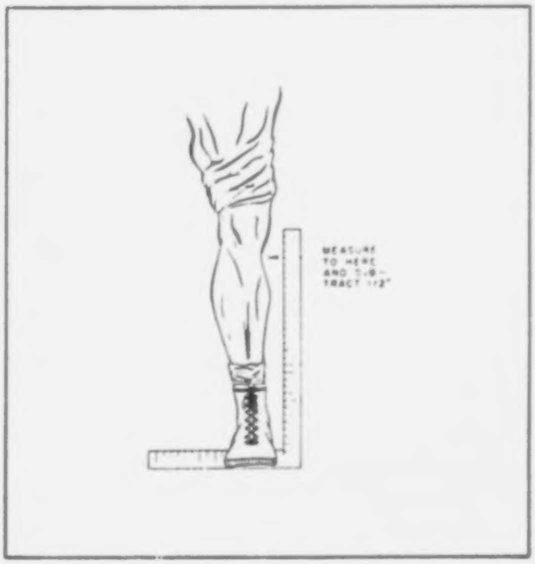


Figure 2-18. Measuring for climber length.

3. Where should the leg strap of the climber be when wearing the climbers?

424. Cite procedures for maintenance and care of pole climbing equipment, and list safety checklist items.

Care of Pole Climbing Equipment. Check your body belt every day; your safety depends on its condition. Be careful to look for cracks or cuts in the leather, thinness due to wear, broken threads in the sewing, loose rivets, a snaphook keeper that is sluggish or fails to act, holes in the tongue that are stretched too large, excessive wear directly under the roller of the buckle, and hard or brittle spots in the leather caused by excessive heat. Bend the belt to determine the presence of cracks and softness of the leather. When bending your belt, keep the grain side of the leather on top and do not curve the belt too sharply, for this causes cracks to be formed. Do not attempt to bend dry leather.

To insure a long life for the body belt, you should clean it frequently with saddle soap or wash it thoroughly with the lather from a neutral soap such as "castile." This action removes imbedded dirt and perspiration and retards rotting. Then, to keep the leather soft and pliable, wipe it dry and oil it lightly with neat's-foot oil.

CAUTION: Never use mineral oil or grease as a preservative. Leather is not to be subjected to excessive heat; therefore, do not wear the equipment when you stand near an open fire nor hang the belts or straps on hot steam pipes.

Preserve the safety strap through use of the methods described in the discussion on body belts. Additional precautions are noted below:

a. Bend the strap over a round object that is not less than 3/4 inch in diameter. Make the test in at least three places, preferably near both ends and once in the middle of the strap.

b. Never improvise a safety strap or attempt to lengthen one with rope, wire, or other unsafe materials.

c. Do not use the safety strap for lifting or pulling objects, or for any purpose other than its intended use.

d. Do not throw or drop the safety strap or body belt.

e. Keep both ends of the safety strap hooked to the D-ring when it is not in use.

f. Wear the safety strap and store it where it will not be damaged by sharp tools.

g. Never punch holes in a body belt or safety strap.

Examine climbers for defective straps or pads and for broken, rusty, or loose gaffs. The normal care for leather preserves the straps and pads. Use a gaff gage to measure the gaff dimensions. Example procedures are illustrated in figure 2-19. Details A and B show the thickness measurements: Detail A shows the gaff inserted through the smallest cutout section marked TH (T on some gages). With the gaff touching the gage, its point should extend to a position between the 1/2-inch and 5/8-inch reference lines. These are the long reference lines in figure 2-19. The B detail shows the gaff in the larger cutout section (TH); the gaff point is resting between the outer edge of the gage and the nearest long reference line.

Use the same principle to check the gaff width. Details C and D of figure 2-19 illustrate the procedures and show again that the gaff point must first rest between the long reference lines and then between the edge of the table and the nearest long reference line.

Detail E shows the procedure for checking the gaff length. The point of a gaff having adequate length will extend beyond the center reference line, as shown. This centerline is 1⅛ inches from either end. Check the gaff tip by inserting it in the same hole in the gaff gage. Detail F shows this procedure and shows what to look for.

Detail G illustrates the check to determine the curvature of the tip. The gaff gage of figure 2-20 shows in closer detail the profile cutout which you use to determine the tip curvature. There is less danger of a gaff "pullout" from the pole if this contour is maintained.

Keep a gaff as near to its original shape as possible. Figure 2-21 shows a file in position for maintaining this shape. It also shows a gaff support rod in position in a bench vise. This is the preferred method for supporting the climber. If such a rod is not available, then position the climber as shown in figure 2-22. Position the gaff so that its point is facing away from you. Then, using a file, firmly stroke the inner surface with an even forward movement from the heel toward the point and at right angles to the gaff's longest dimension. On the return stroke, raise the file from the surface. Do not round the corners or scratch the leg iron.

Figure 2-23 shows the metal that was removed during the sharpening. Take care that you remove as little as possible. The figure also reviews the specification we noted before—the gaff (even when sharpened) should be not less than 1⅛ inches long. Figure 2-24 is another way of reviewing and emphasizing the proper inner surface appearance. The gaff must have an outward curve at the tip and a rounded outer surface. If climbers are unsafe, as shown in figure 2-25, replace or repair them.

Exercises (424):

1. What procedure should you perform daily before wearing climbing equipment?

2. What are the leather defects you should look for on the body belt, and the safety, leg and ankle straps?

3. List faulty conditions to look for on metal pole-climbing equipment parts.

4. How do you keep leather equipment in good condition?

5. How do you determine whether the climber gaff meets the specifications?

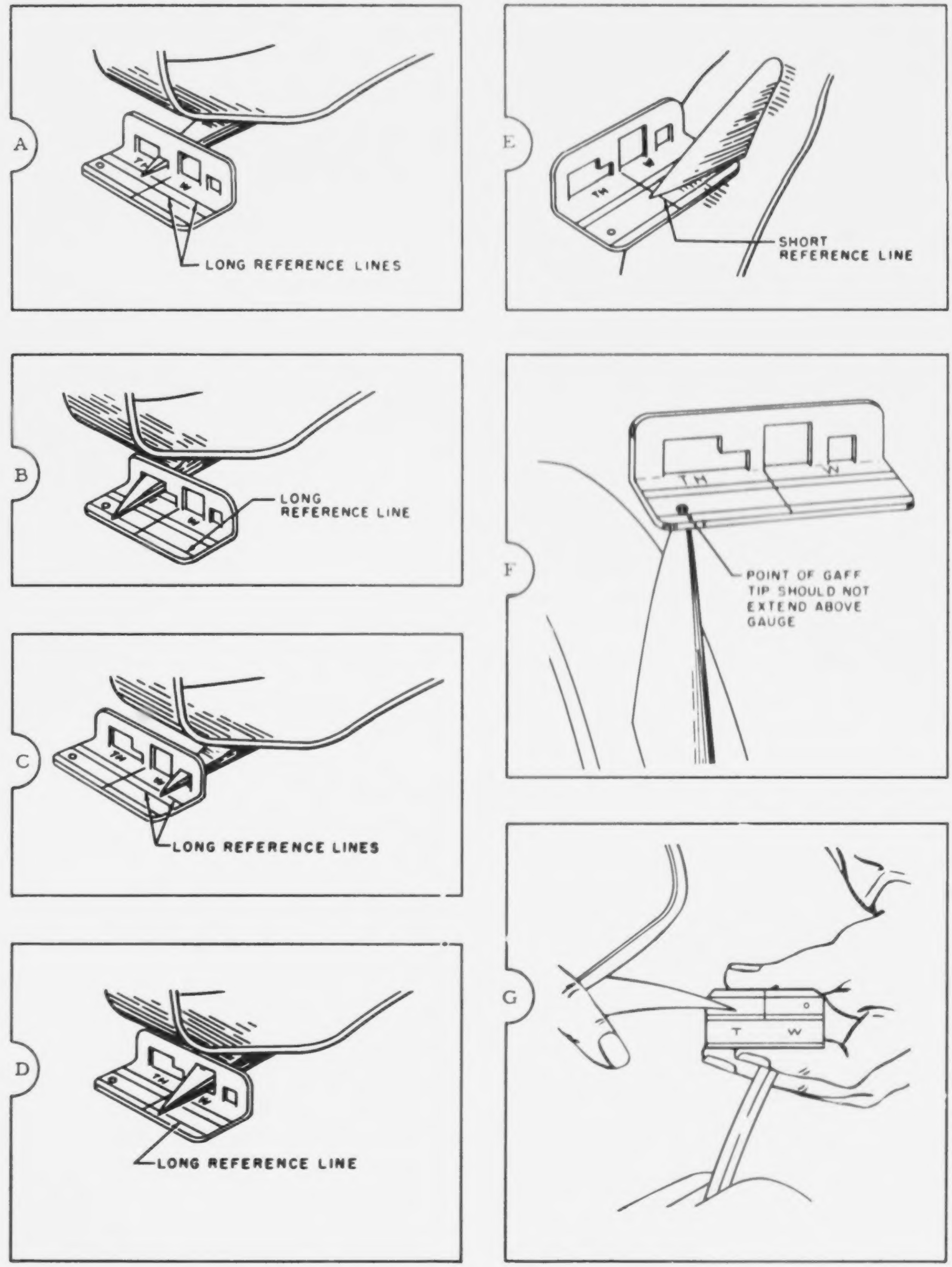

A
TH
W
LONG REFERENCE LINES
E
TH
W
SHORT REFERENCE LINE
B
LONG REFERENCE LINE
F
TH
W
POINT OF GAFF TIP SHOULD NOT EXTEND ABOVE GAUGE
C
TH
W
LONG REFERENCE LINES
G
T
W
D
TH
W
LONG REFERENCE LINE

Figure 2–19. Checking the dimensions of a gaff.

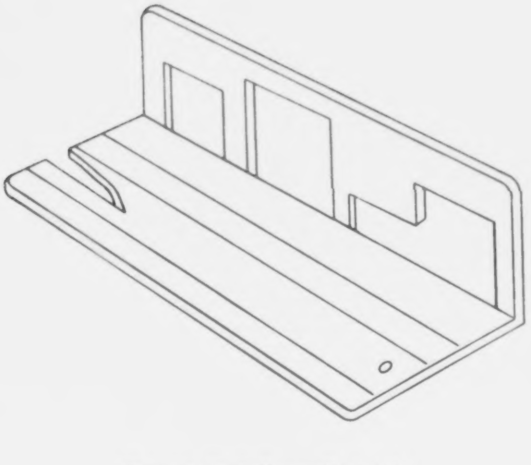


Figure 2-20. Gaff gage illustrated.

425. State safeguards for pole climbing and give procedures to use when climbing.

Pole Climbing. To climb poles safely, you must learn to use climbing equipment in the proper manner. To use this equipment safely and effectively, you should follow these precautions:

a. Never wear climbers where they are not needed; that is, do not wear them when working on the ground, on a ladder, or in deep snow.

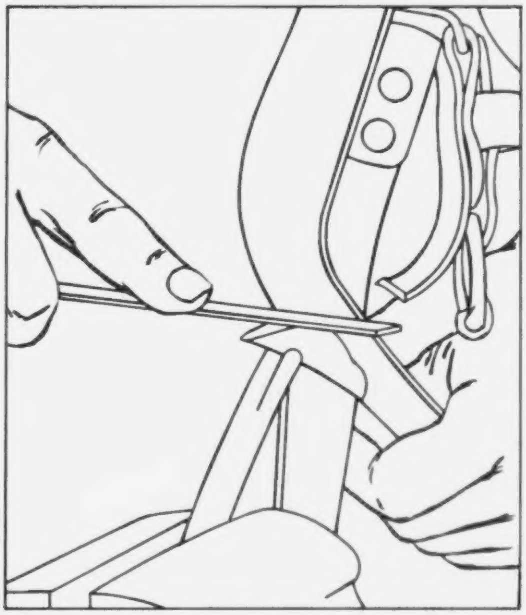


Figure 2-21. Inner surface filing of gaff.

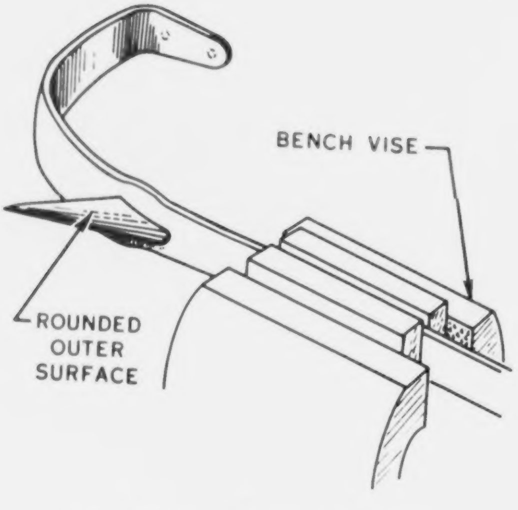


Figure 2-22. Climber protection during filing.

b. Before climbing, test the snaphook and D-ring. Never rely solely on the click of the keeper in the snaphook when attaching a safety snap to a D-ring. Make sure that the parts are secure.

c. Always have the keeper of the snaphook away from your body when the snaphook is fastened in the D-ring.

d. Do not place the safety strap around the pole within a foot of the top of the pole.

e. In placing the safety strap around the pole, make sure that the buckle is securely fastened and that the strap is not twisted.

f. When working on a ladder, do not fasten the safety strap to the ladder.

g. If possible, do not put climbers in the same container with body belt and safety straps; however, if you must, take care to keep the gaffs from punching or cutting the belts or straps.

NOTE: To protect your arms and hands, always wear long-sleeved clothing and wear gloves when climbing.

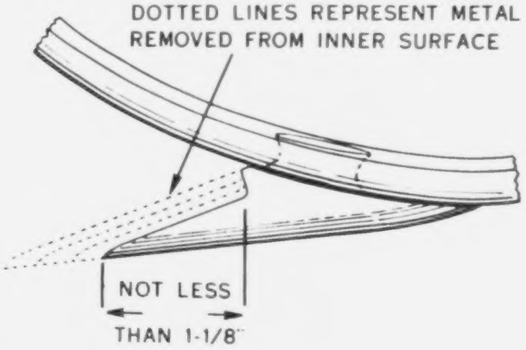


Figure 2-23. Resharpened gaff.

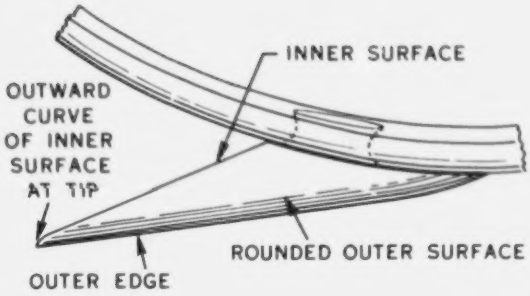


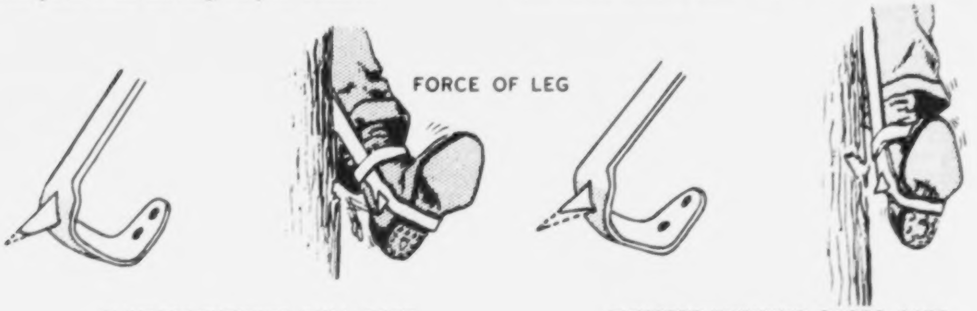
Figure 2-24. Gaff inner surface appearance.

Using climbers to climb poles is relatively simple as long as you follow these precautions and use the proper techniques. For example, in climbing a pole, keep your arms only slightly bent and your hips farther from the pole than any other part of your body. To stick the climber gaffs into the pole, thrust your legs inward and downward. To pull them out, move them upward and outward. If your body is too close to the pole, your gaffs may cut out of the wood. Check your position by placing your hands on the far side of the pole. If your hands overlap, your body is too close to the pole; the gaffs may break out of the wood and cause you to lose your footing. If your hands reach only the side of the pole, your body is too far away. Then your palms have no grasp and your arms are under a great strain. Carry the weight of your body normally; your weight should rest entirely on the gaffs, with your arms serving only to balance.

The position of your hips is also important. If they are too close to the pole, your legs will be parallel to the pole and the gaffs will cut out. But if your hips are too far out, your arms are again placed under strain because they will be supporting too much of your weight. If your knees are bent so that they touch the pole, the gaffs will cut out. Note in figure 2-26 that the lineman keeps his knees and body straight, and as a result, the gaffs are forced into the pole rather than down the pole.

Always inspect the pole before you begin climbing. Note the location of wide weather cracks and hard or soft spots in the wood. Next, study the equipment on the pole, such as cables, crossarms, or other obstacles that may interfere with climbing. Then see if the pole leans. If so, you should face the direction in which the pole is leaning and climb on the high side. If you suspect that the pole is old, with possible breaks or a soft center, be sure to test it before climbing. Never, under any conditions, climb a weak pole without adequately reinforcing it first.

To climb, grasp the pole with one or with both hands and raise your left foot about 10 inches from the ground, keeping the gaff about 1 inch from the pole. Then, with a downward thrust, jab the gaff of the climber in the face of the pole at a point about 8 inches from the ground. Now that the gaff is firmly embedded, lift the weight of your body on the gaff by straightening the leg. Keep the leg holding your weight straight and away from the pole. Although this is a simple habit to develop, it is a fundamental climbing rule. In this way the gaff holds your weight while you grasp the pole with both hands to keep your balance. Now you can raise the other



CLIMBERS SHOWING DULL GAFF

CLIMBERS SHOWING SHORT GAFF

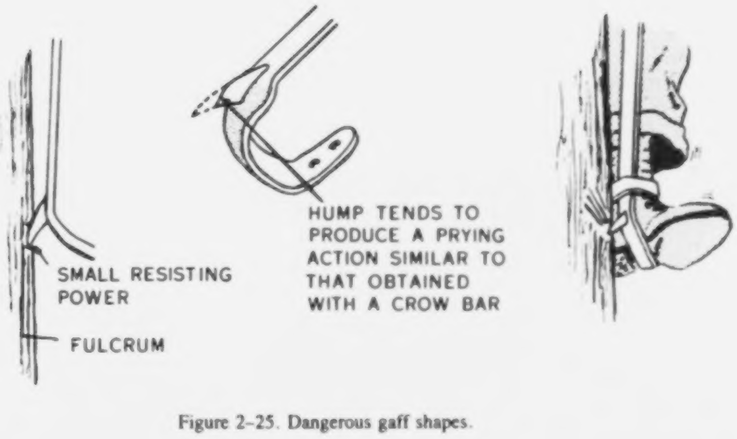

SMALL RESISTING POWER
FULCRUM
HUMP TENDS TO PRODUCE A PRYING ACTION SIMILAR TO THAT OBTAINED WITH A CROW BAR

Figure 2-25. Dangerous gaff shapes.

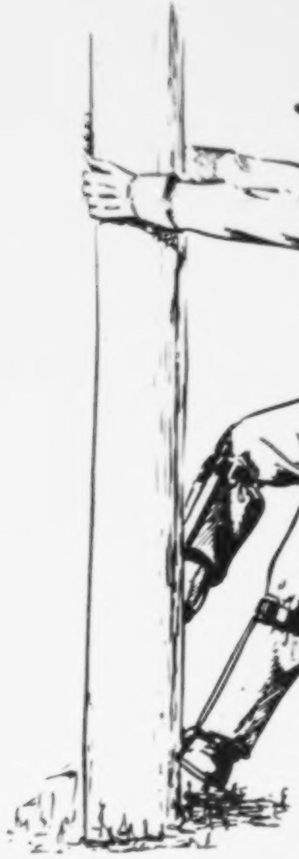


Figure 2-26. Beginning the climb.

leg and the opposite arm and drive the climber downward to seat the second gaff firmly, as shown in figure 2-26. Then you are ready to take the next step upward by pulling up and out on the first gaff and moving your foot upward. Reseat the gaff with the same motions used in taking the first step. Be sure to move your hands upward with each step; otherwise your feet may begin to climb past your hands.

All other steps in climbing are merely a repetition of the first steps that you take on the pole. Follow this sequence of motion until you reach the desired height. One thing to remember while climbing is always to look upward. Your feet will take care of themselves, as long as your head doesn't butt into a crossarm.

When descending a pole, reverse the ascending motions. First, break one gaff free of the pole, using the same upward and outward motion that you used in breaking it for climbing. Then flex the other knee and allow your free foot to move down the pole for the distance of a convenient step. Remember, always look down when descending because you must see where your feet are going. If your gaff hits a knot or other obstruction, you may lose your balance.

After you have learned to climb up and down the pole, you are ready to work on it. If you are to stay in one position and have your hands free for the job, you must know how to fasten the safety strap. At the desired height, shift your weight to one foot. (If you are a right-handed person, put your weight on your left foot.) Then thrust the right gaff into the pole at a slightly higher level than the left gaff. Now place your right hand around the pole, as illustrated in figure 2-27. With the thumb of your left hand, open the keeper of the snaphook and shift the freed end of the safety belt strap around the pole to your right hand. Now, following the example of the lineman in figure 2-28, transfer the snaphook and equipment to your other hand while balancing your body with your left hand. With your left hand, hold the strap up loosely around the pole; with your right, pull the strap to the right-hand D-ring and snap the hook into the D-ring. CAUTION: Remember to see that the snaphook is properly fastened. After all, the keeper can snap without catching the hook, so be sure that the snaphook is secure, as shown in figure 2-29. Now put your right hand back on the pole and move the right gaff to approximately the same level as the left gaff. Then you can lean back and carefully place the full weight of your body on the body belt and safety strap. Keep your hands firmly gripped about the safety strap until the snaps, hooks, and belt have been completely tested. Figure 2-30 shows the installer testing the body belt. Notice the knees. They are straight and under little muscular strain,

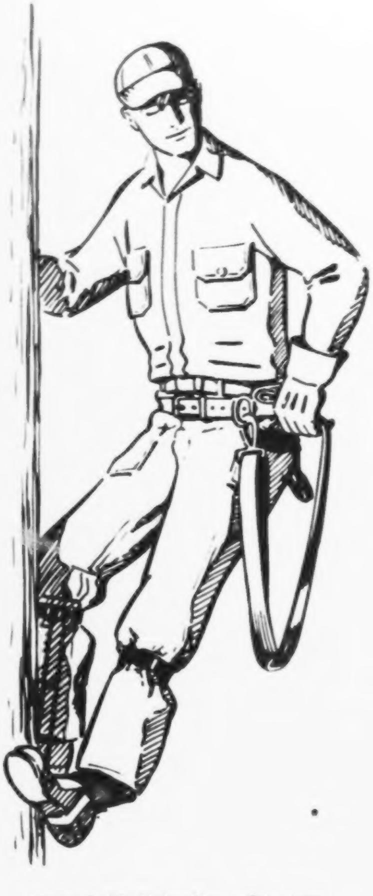


Figure 2-27. Unhooking safety strap.

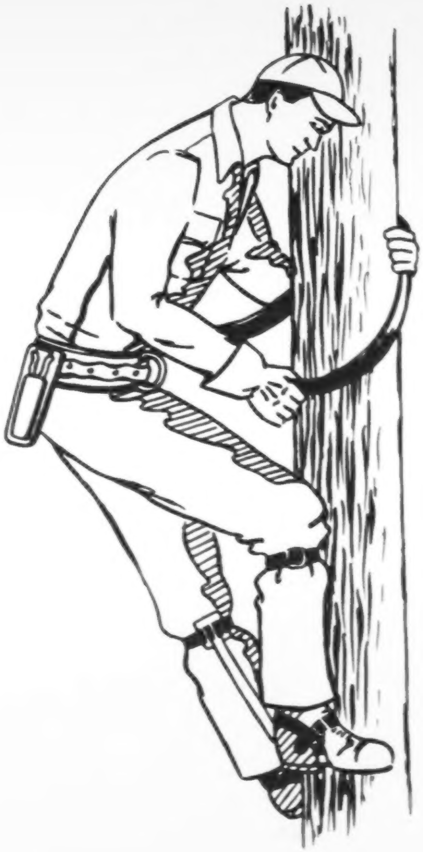


Figure 2-28. Transferring the safety strap.

because the leg bones are supporting the weight. With the knee joints in this position, a person can work with little leg fatigue.

Unfasten the safety strap in reverse sequence. That is, first move the right gaff up and thrust it in at a slightly higher level than the left gaff. Second, hold the pole with your left hand and unfasten the snaphook from the D-ring with your right hand. Now you can pass the strap around the pole to your left hand while balancing your body with your right hand. Lastly, snap the hook to the left-hand D-ring with a single downward movement. As you become experienced in climbing poles, these fundamental procedures and sequences will become routine.

Exercises (425):

1. State three safety rules to observe when wearing climbers.

2. State two safety rules concerning the snaphook.

3. List three safety rules for safety strap placement.

4. Identify the first action required when preparing to climb a pole.

5. List five basic climbing requirements.

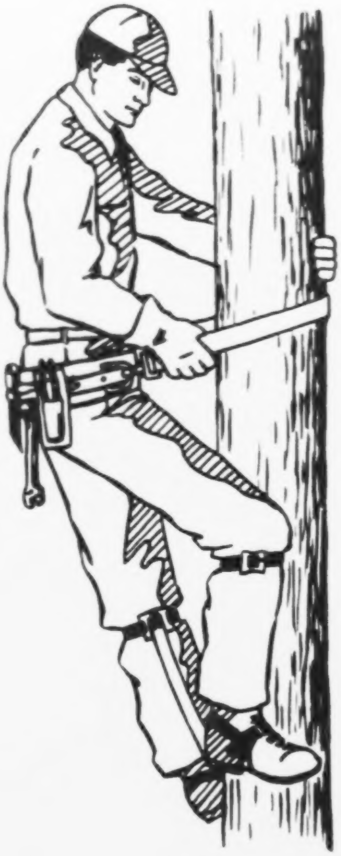


Figure 2-29. Insuring security of snaphook connections.

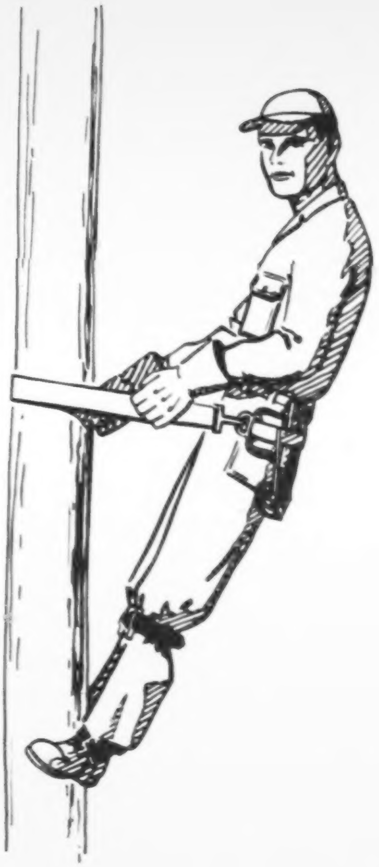


Figure 2-30. Testing body belt.

CHAPTER 3

Terminal to Telephone Wiring

THE INSTALLATION of terminal to telephone wiring completes a large part of the job of installing a telephone. As a matter of fact, when the wiring is completed from the terminal pole to the telephone location, the job of finishing the installation is mostly that of connecting and testing the telephone.

The wiring system from the terminal to the telephone includes the following:

- The drop wire attachments on the pole and building.
- The drop wire run from the pole to the first building attachment.
- The building run from the first to the last building attachments.
- The protector and ground system.
- The building entrance and inside wiring.
- Connecting block and telephone cord.

It is the purpose of this chapter to discuss the components of the terminal to telephone wiring system. However, since termination of the drop wire at the terminal pole is explained in a later chapter, we will not cover it here.

3-1. Drop Wire Installation Requirements

That portion of the drop wire between the terminal pole and the first building attachment is called the span run. The general requirements for clearance, appearance, and future development will apply here as well as to other portions of the drop wire run. When installing the drop, you should economize by using the old attachments (either brackets or knobs) which you find on the pole—if they are suitably located. Of course, the drop installation requires a secure fastening at each end of the wire; therefore, select the correct hardware and use proper installation methods. The following paragraphs define and explain the use of pertinent hardware items.

426. Using figures 3-1 through 3-5, name hardware for outside telephone runs and specify where the hardware items are attached.

Installation Hardware. To consider the attachments (hardware) for an outside installation, let us start at the pole end of the span run. With most aerial cable installations, the telephone cable is supported by a suspension strand which extends from pole to pole. This strand is shown in figure 3-1 with the cable omitted. In an actual installation, lash the cable to the lower side of the strand. Figure 3-1 illustrates the use of span clamps.

Span clamp. As you can see in this illustration, the span clamps attach to the top of the strand to support the drop wire leading to the stations. This is the same type of installation as shown in figure 1-10 where the span clamp was used in avoiding a tree. For a closeup view of some typical span clamps, refer to figure 3-2. The uppermost (A) clamp is made from solid metal with a groove for the suspension strand in each half of the clamp. The lower one (B) is made from heavy sheet metal which is stamped and beat into shape.

Drop wire clamps. To attach the drop wire to the drive hooks and span clamps as shown in figure 3-1, use drop wire clamps. To give you a better view of this item, a typical drop wire clamp is shown in figure 3-3. This device consists of a loop, wedge, and sleeve which grips the drop wire to support the span. Not only do you use the drop wire clamp at the pole end of the span, but also use it on the building to fasten the drop wire to the attachments. By using drop wire clamps to support the span run, you can keep slack in the drop wire at all points of attachment. This minimizes the strain placed on the drop wire by such attachments as drive hooks, drive rings, building attachments, etc.

Although the wire span is normally fastened to the attachments by drop wire clamps, the means of attaching to the pole or the building depends upon the particular job. For example, you may make the drop wire run from a pole which has a guardarm or from a pole that does not have one. Also, if you make the drop wire run from an open wire line, secure it to a crossarm. Consider separately hardware used to anchor the drop wire or drop wire clamp for each end of the drop. Both the drive hook, which must be hammered into the pole (fig. 3-4), and the guardarm hook, bolted through the guardarm (fig. 3-5), are suitable for the pole end of the drop. The attachment on the building, where the work begins, is determined by the structure.

Exercises (426):

1. Using figure 3-1, identify the three telephone drop wire units shown at the pole.

2. Name three units to which drop wire clamps attach.

3. Identify the telephone system unit to which you attach a span clamp.

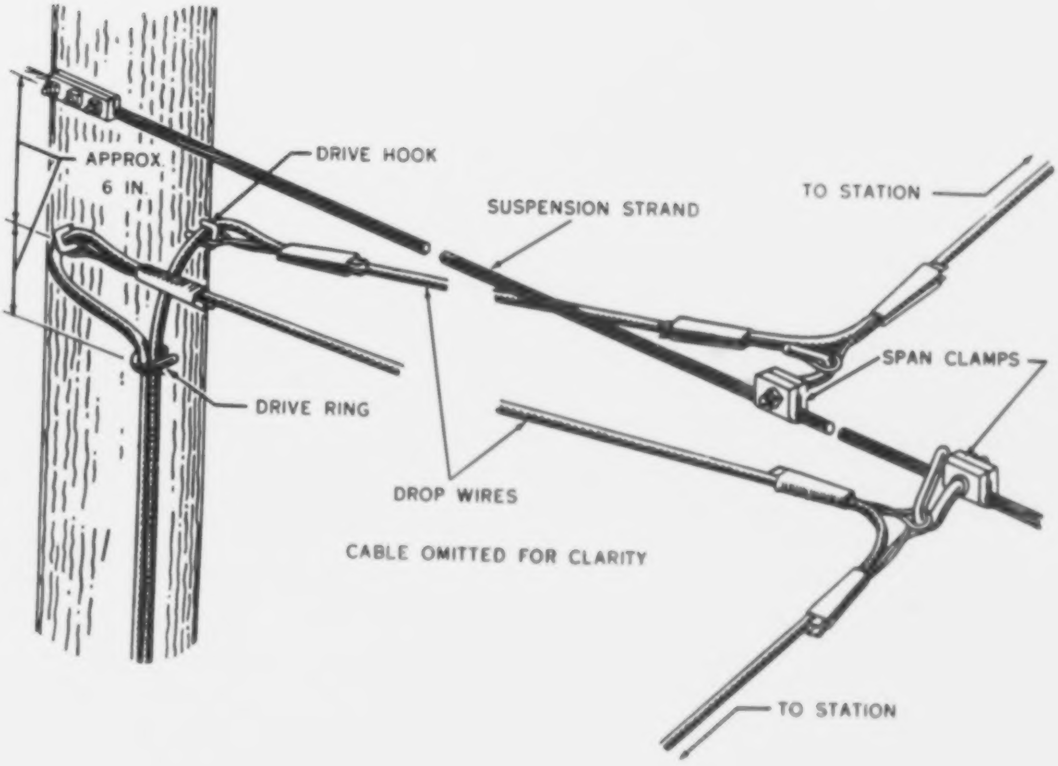

APPROX. 6 IN.
DRIVE HOOK
SUSPENSION STRAND
TO STATION
DRIVE RING
SPAN CLAMPS
DROP WIRES
CABLE OMITTED FOR CLARITY
TO STATION

Figure 3–1. Pole to span-clamp run.

4. Identify the drop wire support unit for which you drill a hole through wood when preparing to install it.

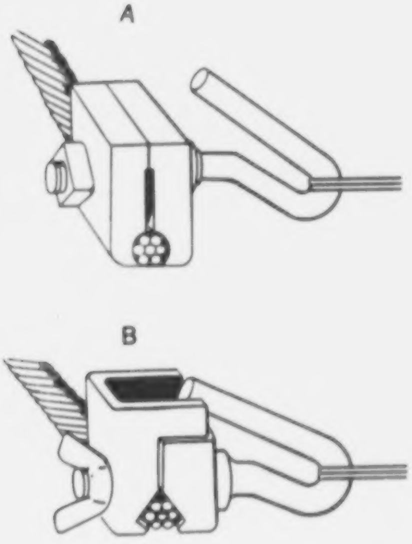


Figure 3–2. Span clamps for lashed cable.

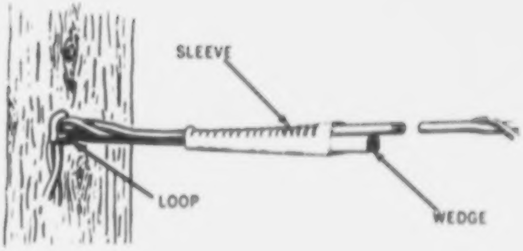

SLEEVE
LOOP
WEDGE

Figure 3–3. Drop wire clamp installed.

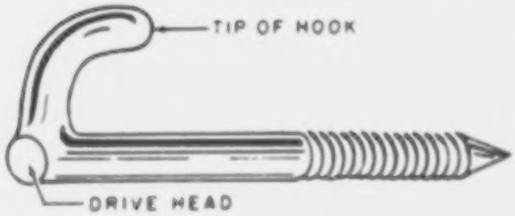


Figure 3-4. Drive hook.

427. Specify precautions to be observed during a drop wire run installation.

Installation Precautions. To install a span run safely, you should observe the following precautions for placing drop wire:

a. Start at the building end of a drop wire span and work toward the pole; thus, you can do all the work on the building run without blocking any of the ground area under the proposed span. In addition, pulling up and sagging drop wire from a pole or strand position is a safer method for the specialist assigned to this job.

b. Position the ladder against the side of the cable suspension strand away from the drop wire span so that the strand is between the span and any person working on the ladder.

c. Do not place the foot of a ladder in a roadway without making adequate provision to guard the ladder from passing vehicles.

d. Do not perform any construction activities from a ladder placed against the suspension strand until after the ladder has been securely tied to the strand.

e. When performing any work operations from a ladder placed against the strand, attach the safety belt to the strand. Do not pass the safety belt between the rungs of the ladder.

f. Do not hold a handline or wire in your hand while climbing a pole or ladder; carry it under your body belt. Double the end of the handline back on itself for approximately 1 foot to form a loop, and place this loop under the side or back of your body belt. After getting in position on the pole or ladder, use the handline to hoist any drop or block wire.

g. During vehicle transportation, keep wire away from sharp-edged tools.

h. When uncoiling wire without a drop wire reel assembly, reverse the coil every five or six turns to minimize the number of kinks in the wire.

i. Do not place drop wire where it will cross above power wires unless specifically ordered to do so.

j. Be very careful to avoid traffic interference when raising or lowering wire across roadways. Obtain assistance to control traffic whenever necessary.

k. When placing more than one drop wire in the building run (this is called a block wire run), make sure that the attachments selected will support the additional weight.

Exercises (427):

Before each listed precaution place a W if the statement relates to wire and an L if it applies to work while on a ladder. Two statements may have both entries.

____ 1. Position it at the suspension strand side and tie securely to the strand.
____ 2. Carry it under the body belt.
____ 3. Keep it away from sharp-edged tools.
____ 4. Protect with road guards.
____ 5. Begin the installation after it is secured to the strand.
____ 6. Place it so that it goes below an installed power cable.
____ 7. Use care when raising or lowering to avoid traffic interference.
____ 8. Reverse every 5 or 6 turns.

428. Correlate installation principles and attachment devices.

Installation Rules. As we said before, the method to use when securing drop wire to the building is determined by the building construction and the telephone cable ground. If the cable is grounded, you may use noninsulated building attachments, such as metal hooks and bridle rings. If the cable is not grounded, you must use insulated attachments on frame or stucco buildings to reduce the possibility of fire caused by lightning or other high-voltage surges. Both the noninsulated and insulated attachments are of the screw type, which you anchor by turning the threaded shank or accompanying screw into the wood.

In your planning for a building run, observe the same rules that apply to the span portion of the drop wire run. For example, locate the first attachment so that the drop will have the necessary clearance above roadways and footways, will clear electric light and power wires, and will be separated from inflammable or conducting materials.

If the installation consists of one drop attached to a masonry or brick veneer structure, you may use one drop wire clamp to carry the weight of the pole-to-building span and another drop wire clamp to support the building run, as

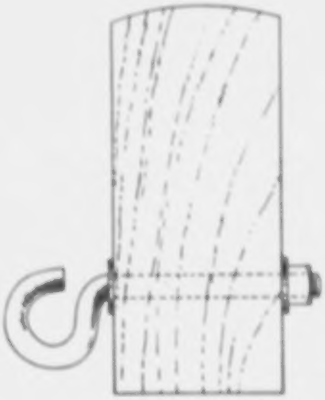


Figure 3-5. Guardarm hook installed (end view of guardarm).

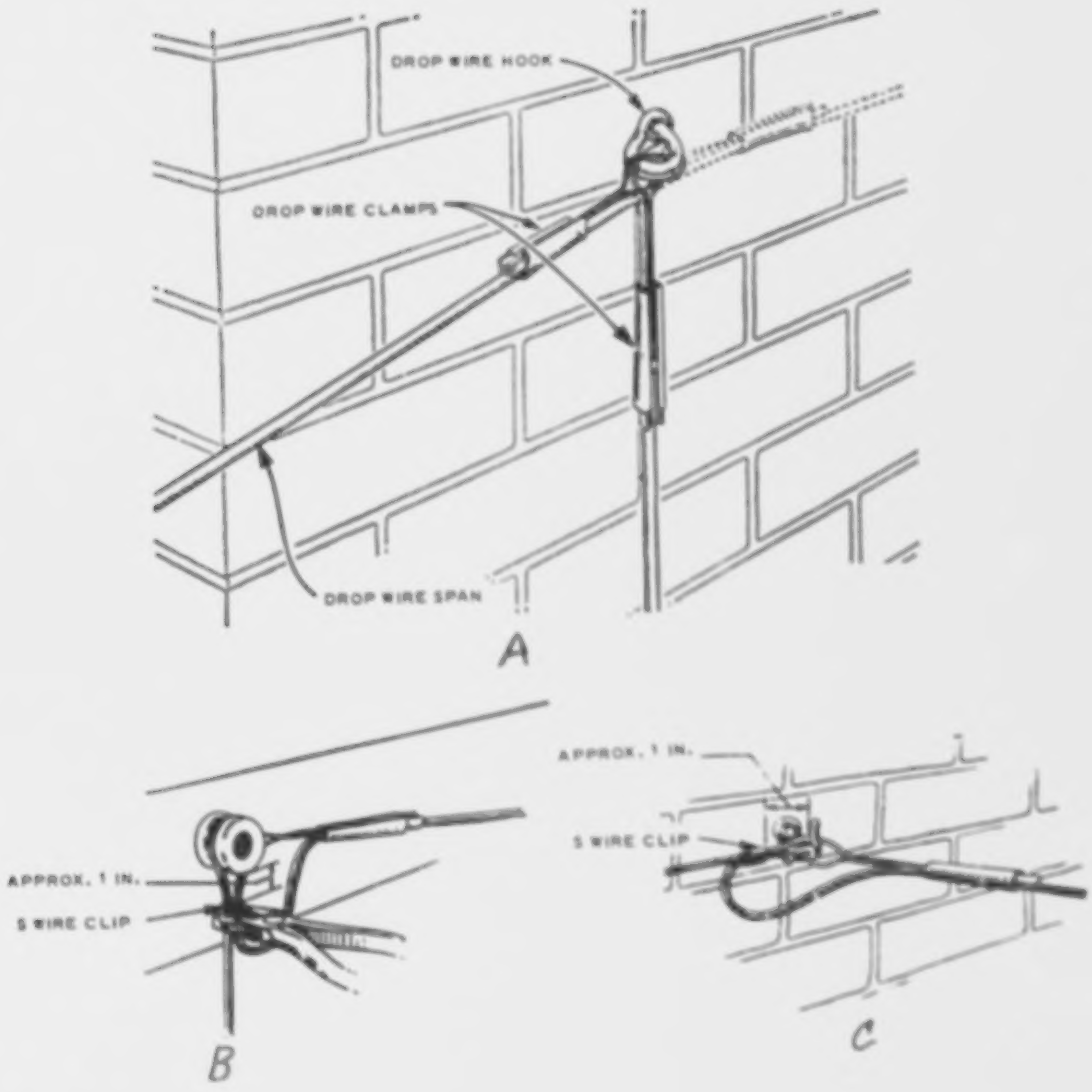


Figure 3-6. Drop wire clamps installed.

shown in detail A of figure 3-6, or you may use an S-wire clip on the building run (see details B and C of fig. 3-6). Note that the S-wire clip may also be used for frame buildings, as illustrated in figure 3-6,B. When you attach a second drop to a drop wire hook, remove the drop wire clamp from the building run of the first drop and place a C-knob (split knob) about 6 inches behind the first span attachment. Figure 3-7 shows this arrangement.

Hardware. Select the hardware for building attachments and follow standard practices when you install them on the various surface types. Usually, you have only one best choice for any situation you face. Figure 3-8 shows S- (single-groove) and T- (two-groove) knobs with insulator supports. Figure 3-9 shows these same knobs with angle screws, and figure 3-10 shows them with brackets. NOTE how the corner bracket with T-knob of figure 3-11 differs from the brackets shown in figure 3-10. When you use these brackets, insulator supports, or screws on frame buildings, they require the knobs shown. You may use the drop wire hooks on frame buildings, as shown in figure 3-12, when the telephone cable is properly grounded. Use an S-knob when only a single drop wire is involved. Two drop wires require a T-knob.

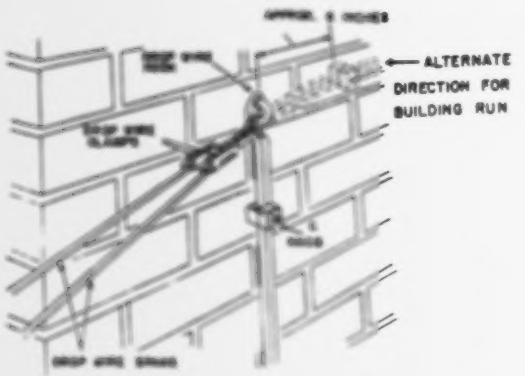

APPROX. 6 INCHES
ALTERNATE
DIRECTION FOR
BUILDING RUN
DROP WIRE SPANS

Figure 3-7. Two drop wire spans attached to building.

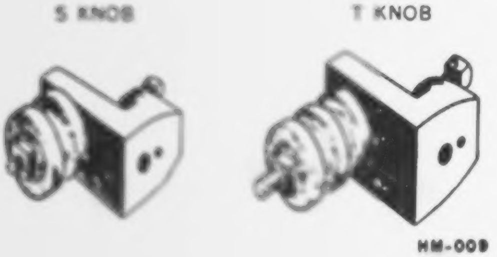

S KNOB
T KNOB
HM-009

Figure 3-8. Universal insulator supports.

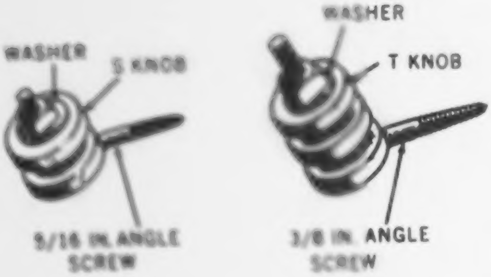

WASHER
S KNOB
9/16 IN. ANGLE SCREW
WASHER
T KNOB
3/8 IN. ANGLE SCREW

Figure 3-9. Angle screws.

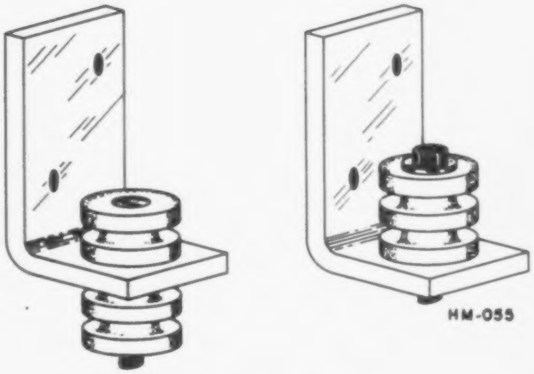


Figure 3–10. House brackets.

On masonry construction, you must provide anchors of some sort for the brackets, hooks, and attachments. Part A of figure 3-13 shows two types of hammer drive anchors with a nail providing the wedging element. In figure 3-13,B, we see the anchor inserted through the mounting hole of the fixture and into the drilled hole in the masonry wall. Driving the nail into the anchor expands the sides, making the anchor fit tightly in the hole. The screw anchor, shown in figure 3-14, operates on the same principle. After inserting the anchor into the drilled hole, place the wood screw through the mounting hole of the fixture and into the anchor. Tightening down on the screw expands the anchor. A bridle ring with a wood screw thread may be used with this type of anchor. Use toggle bolts, similar to those shown in figure 3-15, on hollow tile or concrete block walls. The hole must be large enough to take the toggle, as shown in the illustration. When you use angle screws, wire hooks, and bridle rings on frame installations, arrange them so that the wire pull turns the screw deeper into the wall.

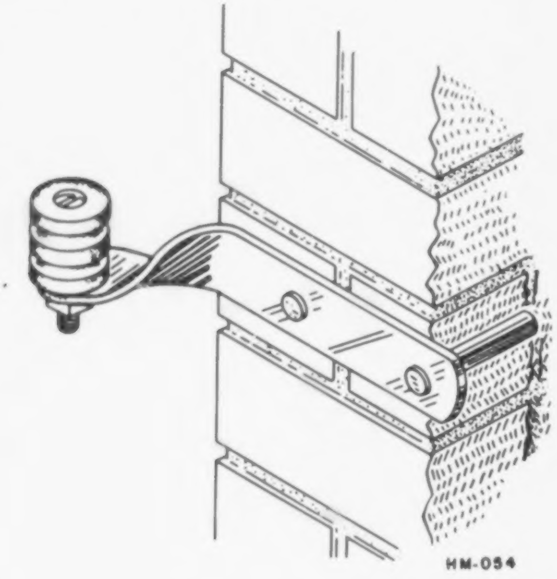


Figure 3–11. Corner bracket.

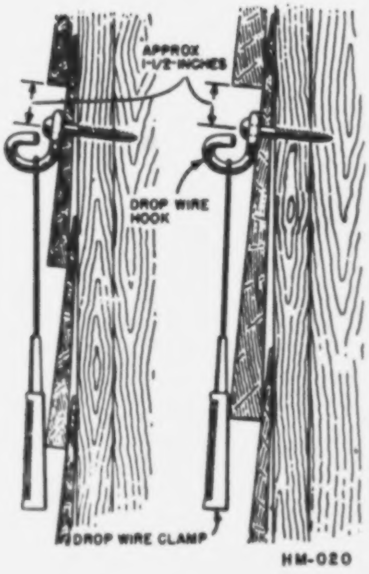

APPROX 1-1/2 INCHES
DROP WIRE HOOK
DROP WIRE CLAMP
HM-020

Figure 3–12. Drop wire hook on frame building.

Between the first and the last building attachments, place the drop wire run on the building by means of rings or screw eyes. These supporting devices are intermediate attachments. Figure 3-16 shows a bridle ring (A) and corner bridle rings (B) installed on brick surfaces. Figure 3-17 shows insulated screw eyes installed on surfaces of wood and stucco on wood. Use the short shank (S-type) on wood surfaces and the longer shank (L-type) with stucco surfaces. Keep the distance between the attachments on horizontal runs within a maximum range of 9 feet, and keep the distance between attachments on vertical runs within a maximum length of 12 feet. Place intermediate attachments so that they will divide as evenly as possible the distance between the first and the turn attachments on a horizontal run and the distance between the turn and last attachments on a vertical run. If the vertical run begins with the first attachment, divide the distance between the first and last attachments. Such placings give the drop more security and a better appearance. When you use additional attachments, make allowances so that exposed wires will clear a frame building and the wires will not slap the building.

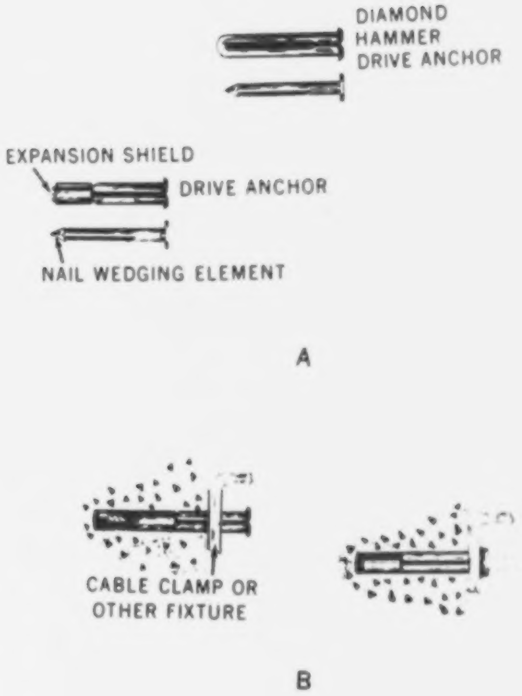

DIAMOND
HAMMER
DRIVE ANCHOR
EXPANSION SHIELD
DRIVE ANCHOR
NAIL WEDGING ELEMENT
A
CABLE CLAMP OR
OTHER FIXTURE
B

Figure 3–13. Drive anchors.

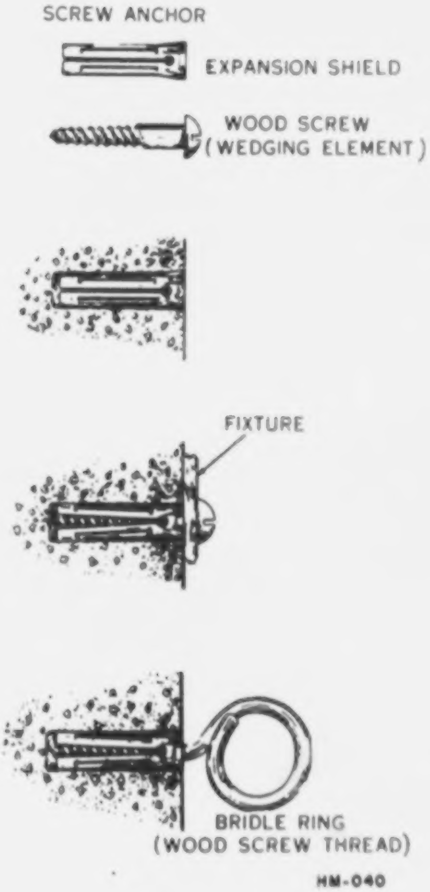

SCREW ANCHOR
EXPANSION SHIELD
WOOD SCREW
(WEDGING ELEMENT)
FIXTURE
BRIDLE RING
(WOOD SCREW THREAD)
HM-040

Figure 3–14. Screw anchors.

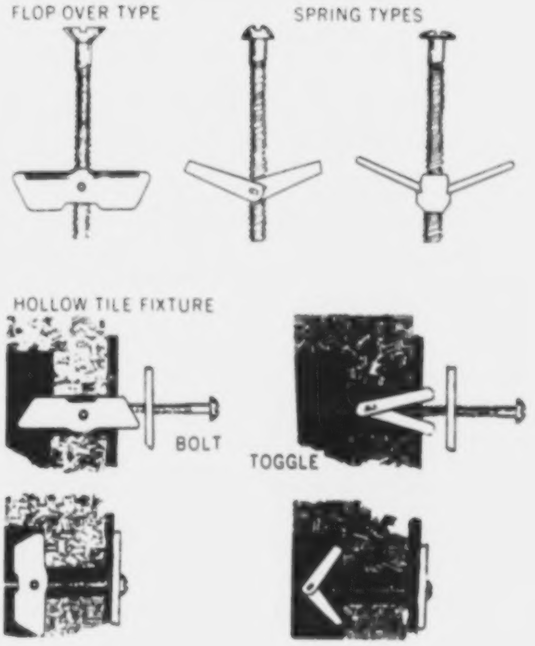


Figure 3-15. Toggle bolt anchors.

Exercises (428):

1. Match the installation rule of column A with the attachment device listed in column B. Remember: Select the best choice for the given situation.

	Column A *Installation Rule*	*Column B* *Attachment Device*
___	(1) Usable on frame buildings when telephone cable is grounded.	a. Toggle bolt.
___	(2) Use on masonry buildings.	b. T-knob.
___	(3) Used with ungrounded cable.	c. S-wire clip.
___	(4) Usable on hollow tile or concrete block walls.	d. Drop wire hook.
___	(5) Install on stucco-on-wood siding.	e. C-knob.
___	(6) Use in conjunction with drop wire clamp.	f. Noninsulated attachment.
___	(7) Place 6 inches behind first span attachment.	g. Insulated attachment.
___	(8) Usable as an intermediate attachment.	h. Hammer drive anchor.
___	(9) Use with two drop wires.	i. Bridle ring.
___	(10) Used with grounded cable.	j. Insulated screw eye.

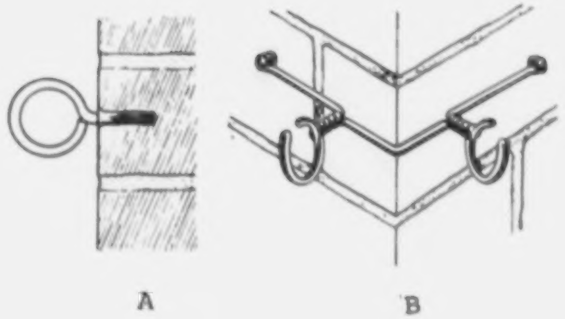


Figure 3-16. Bridle ring installation.

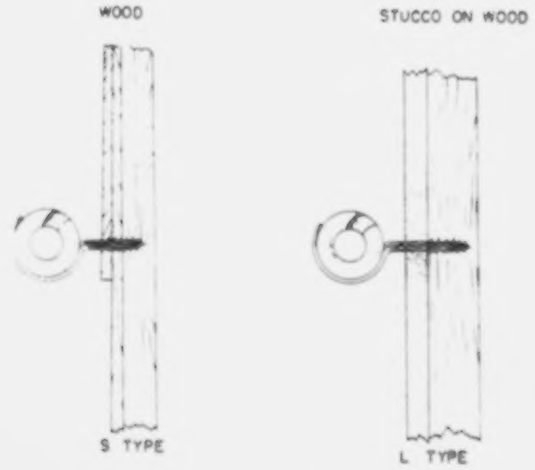


Figure 3-17. Use of short and long insulated screw eyes.

429. For a given telephone system protector, give an installation feature or requirement for it.

Protection. Provide mechanical protection on the building run whenever necessary by installing friction tape, rubber and friction tape, or using an insulating tube on the wires of the building run at the points requiring protection. Use friction tape only on noninsulated runs at obstructions other than open electric, radio, ground, or signal wires. Use both rubber tape and friction tape or an insulating tube when mechanical protection is required on insulated building runs.

Insulating tubes are of two types: solid and split. Use the solid tube for a new building run installation and for existing installations that require such protection. Use the split tube only for existing building runs when a solid tube installation is not practical. Using the split tube makes it unnecessary to disconnect or cut an existing wire in order to thread it through a solid tube. Tubes come in three sizes: 3/8-, 3/4-, and 1-inch diameter.

Always select an insulating tube with a large enough diameter to accommodate the ultimate number of wires that will be placed in the building run. Except at entrance holes, use a tube that is long enough to extend at least 2 inches beyond each side of the object to be crossed by the drop or block wires. After tubes are cut to the correct length, remove all sharp edges at the cut end with a carborundum stick.

Install a solid insulating tube by passing the end of the drop wire through the tube and sliding the tube along the wire to the desired location. Install a split insulating tube by securing the two halves of the tube around the drop wire with lashing wire about 1 inch from each end of the tube to keep the tube halves together. Twist the ends of each lashing wire together and bend the twisted ends back against the tube so that they will not catch on clothing or hurt anyone.

After you have positioned an insulating tube, secure it in place on the drop wire with a drop wire clip, drive ring, split knob, or insulated screw eye at each end of the tube, as shown in figures 3-18 and 3-19.

In using rubber tape to protect drop wire, place enough tape around the wire to provide a cover for at least 2 inches past both ends of the obstruction. Then cover this length of the wire with two reversed half-lapped layers (four thicknesses) of 3/4-inch rubber tape applied with enough tension to double the tape length. Start at the center of the obstruction and wrap the tape out to 2 inches beyond the other end of the obstruction. Now reverse wrap to 2 inches beyond the other and of the obstruction. Reverse wrap again and end at the center. Place friction tape over the layers of rubber tape.

When the drop wire runs behind a rainspout, place the supporting attachments at the ends of the protection. If you use tape protection at a rainspout on masonry surface, you may position the supporting attachments away from the ends of the protection to provide a more convenient position for the attachments, as shown in figure 3-20. In no case, however, should you place the supporting attachments more than 12 inches away from the ends of the obstruction.

When the drop wire runs in front of a rainspout, place the supporting attachments not more than 12 inches from the ends of the obstruction and in such a way that they will hold the protected portion in place against the rainspout without causing any sharp bends in the wire. If an insulating tube is used for protection, secure the tube in place with a drop wire clip placed at each end of the tube (detail B-B, fig. 3-19). If drive rings are used, tie the drop wire to the drive rings (detail A-A, fig. 3-19), using a short length of bridle wire for each tie.

Exercise (429):

1. Match the protector of column B to the applicable statement of column A. A protector will be used two or more times.

Column A
Feature or Requirement

___ (1) Place 12 inches from obstruction end.
___ (2) Secure with twisted lashing wire.
___ (3) Intended for new building run.
___ (4) Length must extend 2 inches beyond the crossed over object.
___ (5) Extend 2 inches beyond both ends of the obstruction.
___ (6) Remove sharp edges with carborundum stick.
___ (7) Place over the first protective wrap.
___ (8) Secure in place with drop wire clip.
___ (9) Use two in reverse with tension.
___ (10) Tie to drop wire with bridle wire.

Column B
Protector

a. Friction tape.
b. Solid insulating tube.
c. Rubber tape.
d. Split insulation tube.
e. Support attachment.

430. Cite additional installation requirements for given drop wire run installations.

Drop wire run. Frequently the drop wire run on the building must turn corners. Figure 3-21 shows the attachments used for guiding the drop wire around an outside corner. In detail A of figure 3-21, we see a corner type bridle ring arrangement, while detail B shows two screw-type bridle rings used to guide the drop wire around the corner. Figure 3-21,C, illustrates two porcelain C-knobs used on wood to turn a corner. Do an inside corner in a similar manner by using screw-type bridle rings or insulated screw eyes. Figure 3-22 shows how to turn corners when the drop wire run changes from a horizontal to a vertical direction. Note that figure 3-22 shows both single and multiple wire installations. If necessary, use drop wire hooks in place of the bridle rings.

The last attachment of the drop wire run on the building is the one just before entrance into the building. Figure 3-23 shows a typical entrance and last attachment. Note that you install the drop wire with a drip loop to prevent moisture from following the wire into the building.

As we mentioned previously, frame structures require knobs and insulated screw eyes for drop wire attachments when the cable sheath is not grounded. Figure 3-24 shows a

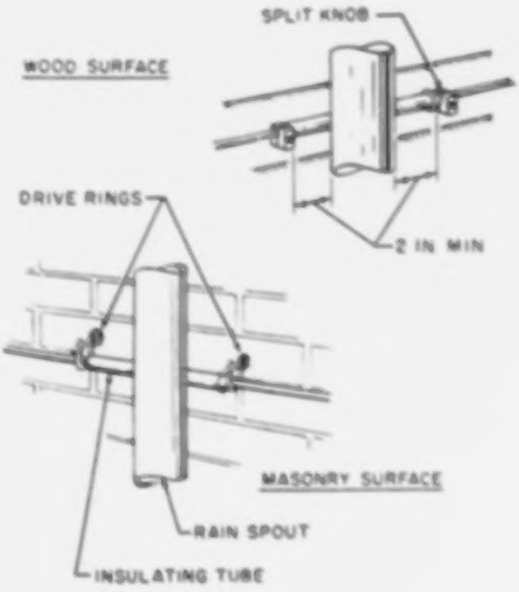


Figure 3-18. Insulating tube installation.

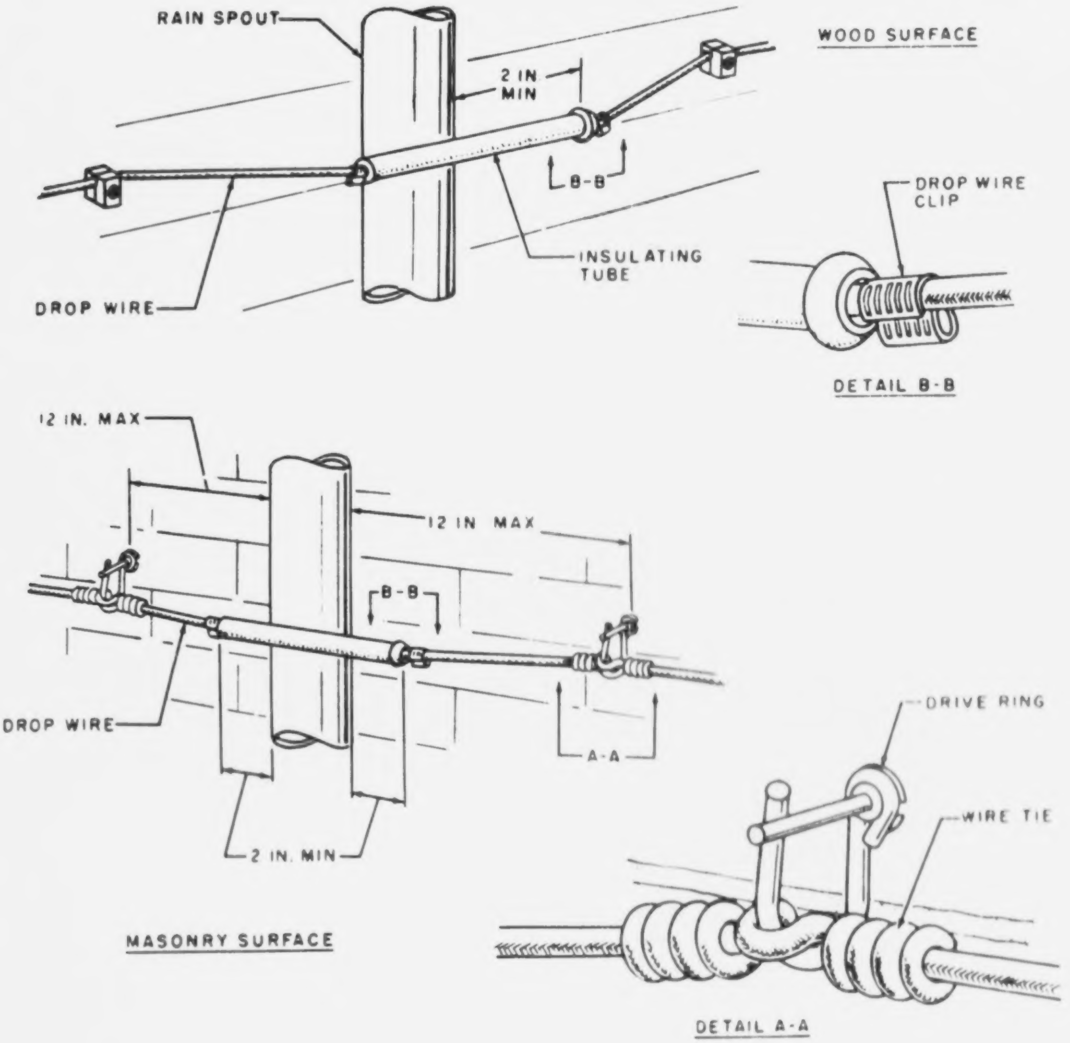


Figure 3–19. Insulating tube attachment.

typical frame building run in which the first attachment is made with a C-knob, and the run includes a horizontal section, a turn made with insulated screw eyes, and a vertical section. Note that the horizontal section, which runs parallel with the building siding from the first attachment to a point above the entrance, avoids windows or other obstructions. Note also that the vertical run does not pass in front of windows and that it is truly vertical as it goes to the C-knob, which is the last attachment.

Remember to place insulated screw eyes at least 5 feet above the ground line in alleyways or other locations close to a street so that the porcelain portion of the screw eye will not be damaged by people who are using the thoroughfare. If lower attachments must be made, use split (C) knobs instead of the insulated screw eyes.

Install drop wire runs on brick buildings by applying the same principles as those used for frame building installations. In figure 3-25 you see that the drop wire run on the brick is attached by drop wire hooks or bridle rings and that the entrance is made near a window. You should place the run along a smooth part of the brick rather than along rough foundations. Be sure that the run avoids obstructions and that the attachments are anchored in the center of the brick rather than in the mortar between bricks.

Stucco construction, as shown by figure 3-26, requires attachments to suit the basic construction of the building. Since the building shown in figure 3-26 is stucco over frame, the attachments shown are those which would be used for a frame building. If the stucco is over a masonry building, you should use masonry type attachments.

Exercises (430):

1. How should building attachments be placed to permit a drop wire to go around a building corner safely?

2. What attachments are installed at the corner of a frame building to protect a drop wire when passing around it?

3. What is the recommended separation distance for building attachments used where a drop wire is changed in direction (from horizontal to vertical)?

4. What installation procedure is required when preparing to insert a drop wire into a hole in a building?

5. State the maximum distance separation between building attachments on a horizontal drop wire run.

6. State the maximum distance separation between building attachments on a vertical drop wire run.

7. What is the minimum distance above the ground that an insulated screw eye attachment must be located?

8. Identify the drop wire support device to use to hold the wire tight against the first building attachment.

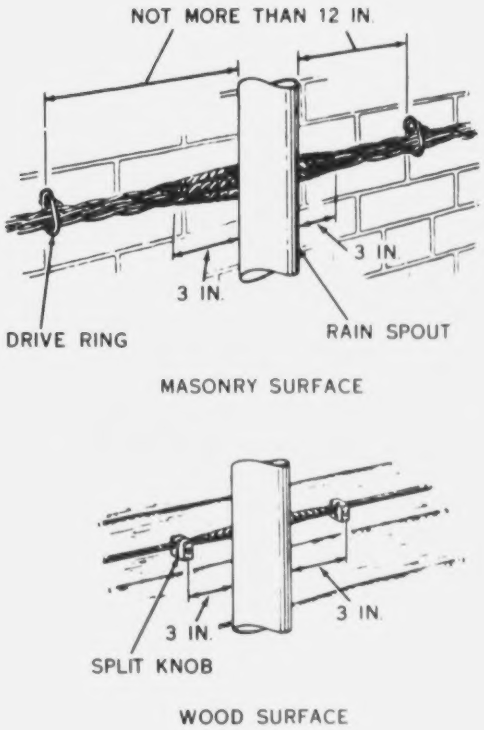


Figure 3-20. Use of protective tape.

431. Specify proper type hook to use in attaching wiring to poles.

Clearances. As we mentioned before, drive and guardarm hooks are used as attachments on the terminal pole. Let us now consider how these attachments are used. Install the guardarm hook and the drive hook according to standard practices. That is, stagger drive hooks at least 1 inch when two are installed on the same pole (fig. 3-27) and place them so that the drop wire has the proper appearance and clearance. The vertical distance from the suspension strand to the drive hook may be varied to obtain proper clearance.

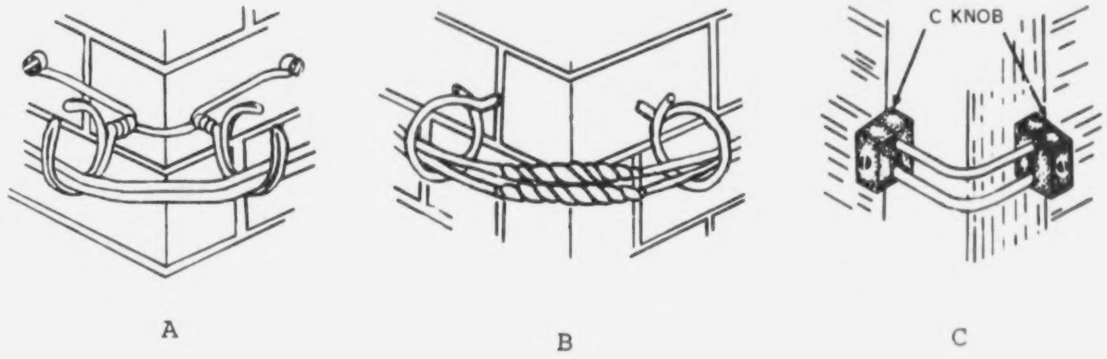


Figure 3-21. Outside corner attachments.

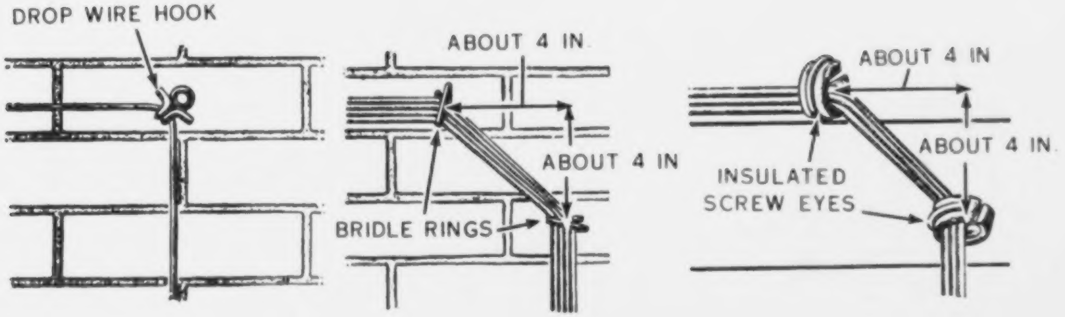

DROP WIRE HOOK
ABOUT 4 IN.
ABOUT 4 IN
BRIDLE RINGS
ABOUT 4 IN
ABOUT 4 IN.
INSULATED
SCREW EYES

Figure 3-22. Turn attachments.

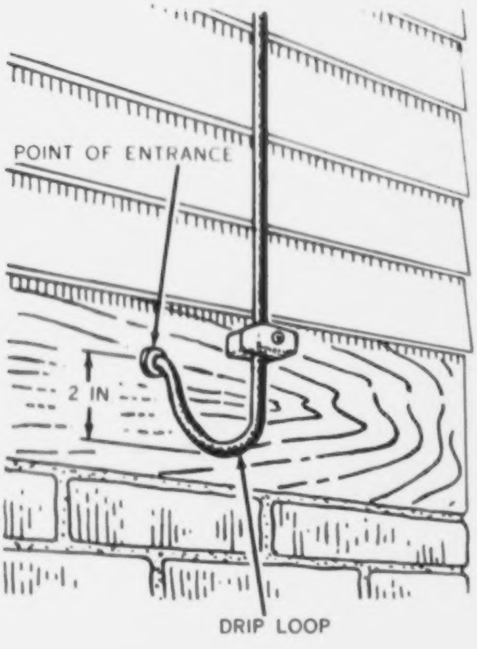

POINT OF ENTRANCE
2 IN
DRIP LOOP

Figure 3-23. Last attachment drip loop.

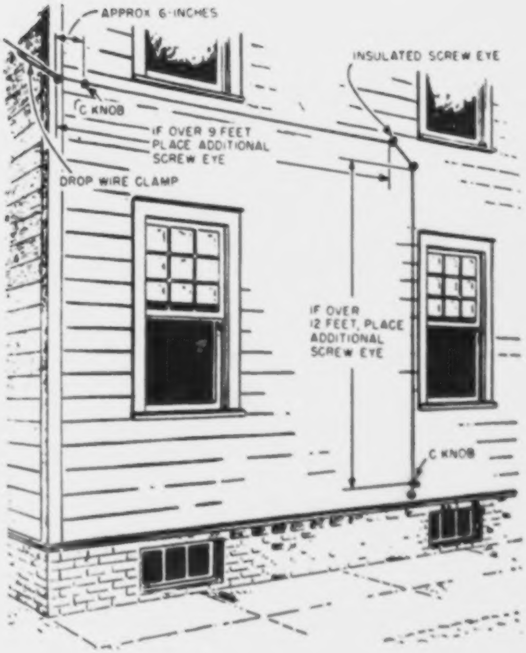

APPROX 6-INCHES
INSULATED SCREW EYE
C KNOB
IF OVER 9 FEET PLACE ADDITIONAL SCREW EYE
DROP WIRE CLAMP
IF OVER 12 FEET, PLACE ADDITIONAL SCREW EYE
C KNOB

Figure 3-24. Drop wire run on frame building.

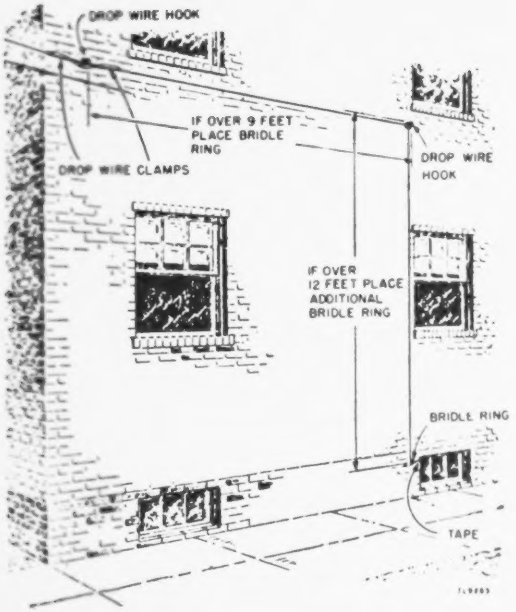
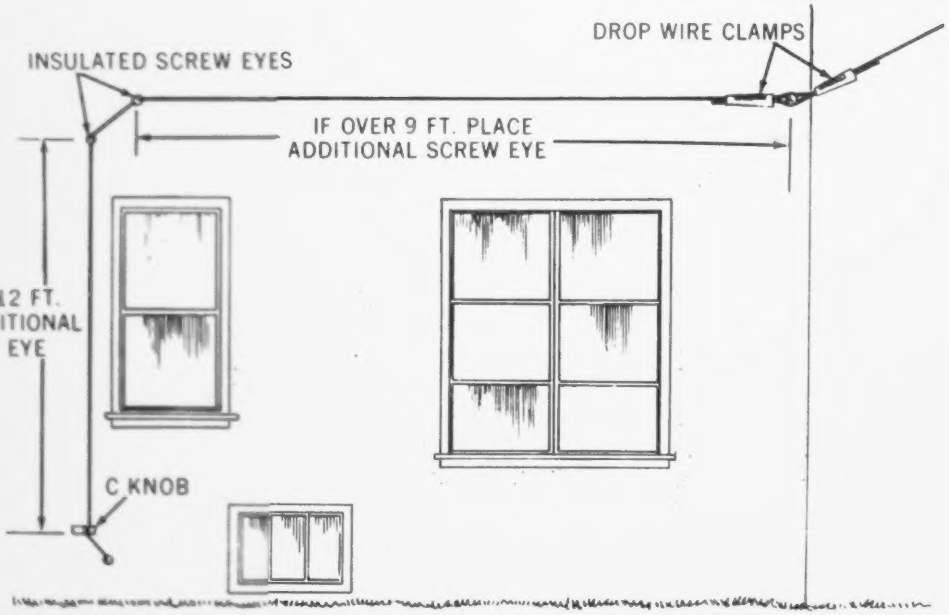

DROP WIRE HOOK
IF OVER 9 FEET PLACE BRIDLE RING
DROP WIRE CLAMPS
DROP WIRE HOOK
IF OVER 12 FEET PLACE ADDITIONAL BRIDLE RING
BRIDLE RING
TAPE

Figure 3-25. Drop wire run on masonry building.


DROP WIRE CLAMPS
INSULATED SCREW EYES
IF OVER 9 FT. PLACE ADDITIONAL SCREW EYE
IF OVER 12 FT. PLACE ADDITIONAL SCREW EYE
C KNOB

AT INSTALLATIONS WHERE STUCCO-FINISH WALLS HAVE NO WOOD BACKING, TURN MAY BE MADE WITH ONE INSULATED SCREW EYE PLACED IN STUDDING.

Figure 3-26. Drop wire run on stucco-over-frame building.

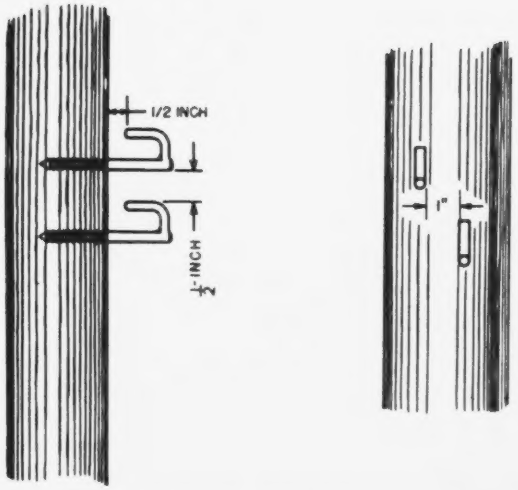


Figure 3–27. Drive hooks installed on pole.

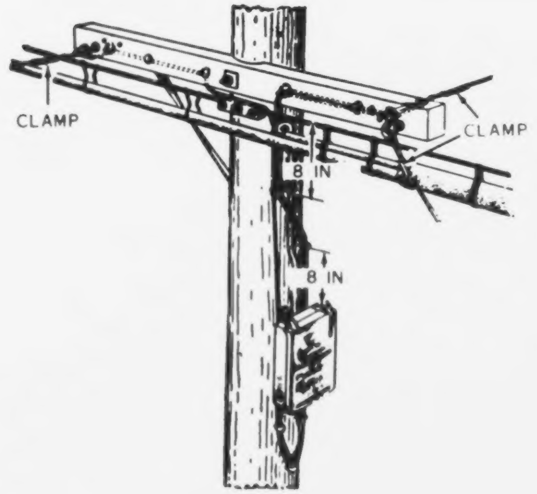


Figure 3–29. Location of guardarm hooks at terminal pole.

Figure 3-28 shows two drops from the same terminal pole. Note the location of the drive hooks and also note in the encircled detail that one drop wire is resting on the shank of the drive hook. This is permissible when the angle between the drop and the pole is such that you can prevent a sharp bend. From the drive hook, the drop wire runs through drive or bridle rings to the terminal. When a vertical run is on the pole, pull the ring wiring taut to eliminate unsightly slack; however, don't pull the wire so tight that the strain is taken off the drop wire clamp and placed on the drop wire itself.

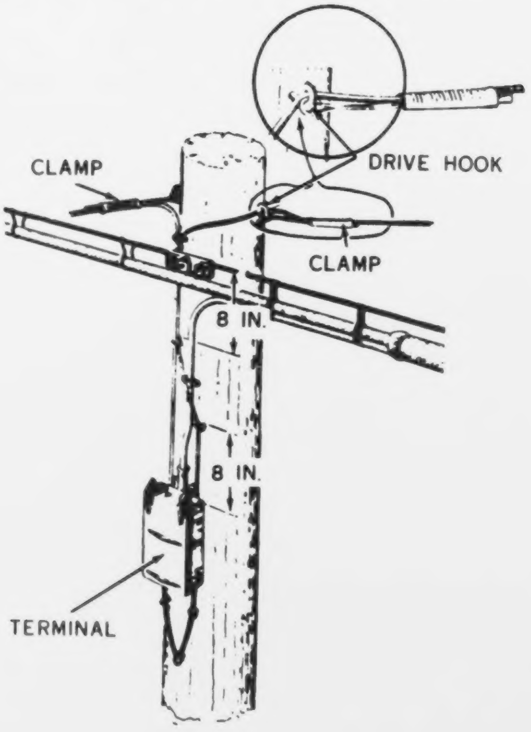


Figure 3–28. Location of drive hooks on terminal pole.

Do not use drive hooks when the pole requires a guardarm; instead, attach the drop wire to guardarm hooks on the guardarm, as shown in figure 3-29. The guardarm hooks provide a solid fastening on the guardarm, just as the drive hook did on the pole. Complete the installation in essentially the same manner. The necessity for avoiding slack and for obtaining the proper clearance applies here also.

When the drop is to be attached to an open wire line, use the guardarm hook on the crossarm in making the installation. When this method is used, make sure that the hook is installed in a position so that the drop wire span will clear the open wire lines.

Exercises (431):

1. How far apart should drive hooks be placed when two are installed on the same pole?

2. How should you attach drop wire to a guardarm?

3-2. Underground Distribution Wiring

At some time or other you may be required to make an underground installation between the terminal pole and the subset. This type of installation usually requires the use of underground distribution wire and, of course, different methods of installation. Figure 3-30 shows a typical single-pair, parallel-jacketed, underground distribution wire, which is available in one- and two-pair sizes. Note that the rubber-insulated conductors are protected by a steel serving and a weatherproof neoprene jacket. On the insulation of one wire of each pair is a tracer ridge or groove.

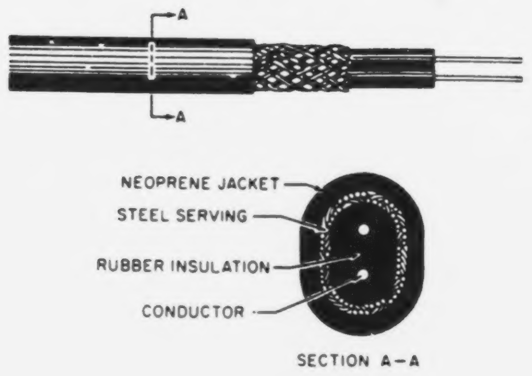


Figure 3–30. Pair arrangmenet of parallel-jacketed underground distribution wire.

When it is necessary to make an underground installation, technical orders on drop wire and station installation will specify the appropriate wire for the job.

432. Cite underground cable installation and burying procedures and precautions.

Burying Cable. The wire or cable for underground service installations may be buried directly in the ground or run through conduit. The usual practice is to bury the wire or cable, unless conduit facilities already exist. But you may have to install galvanized-pipe conduit to provide mechanical protection at critical points or locations of directly buried runs, such as runs across drainage ditches, roadways, small bridges, and through culverts.

If soil conditions permit and a wire plow is available, plow the underground distribution wire or service cable under the ground. Dtherwise, bury the wire in a hand- or machine-dug trench, which should not generally be more than 12 inches wide. The width, however, will depend on the conditions of the job location and the digging tools available.

Buried Cable Precautions. All personnel burying wire must observe the following precautions:

a. Be sure to bury the wire or cable deep enough to prevent damage by heavy vehicles crossing the buried line.

b. When placing wire along roadways or across ditches, avoid locations that might interfere with natural drainage.

c. Avoid careless handling of wire and reels while they are in transit and during the placing procedures.

d. Do not remove lagging from the wire reels until the wire is ready to be placed in the ground. Exposure to light and moisture may cause deterioration of the rubber insulation; therefore, cover exposed reels with a tarpaulin when the weather is wet.

e. Do not permit vehicles to be driven over wire or cable that is lying on the ground.

f. If the wire or cable is to be placed in an excavated trench, check the wire or cable carefully for cuts, nicks, and breaks as it is placed. Make any necessary repair or replacement.

g. Allow a sufficient length of the wire or cable to extend at both ends of the run to permit proper terminations.

Placement depth. In general, a depth of 18 to 20 inches will provide a good, protective earth covering for buried wire or service cable. The actual depth of placement, however, will depend on the conditions along the wire route and the operating efficiency of the digging and burying tools and equipment.

If you cannot meet the minimum placement depths listed in pertinent tables, provide additional mechanical protection or select an alternate wire route. For example, mechanical protection, such as galvanized pipe, split wood conduit, and U-cable guards, is necessary for underground distribution wire or service cable at locations where the wire or cable is, or is likely to be, exposed to mechanical damage or weathering.

Galvanized pipe. When buried service wire must cross roadways or streams, use galvanized pipe for protection. Figure 3-31 shows a pipe installation in which the pipe is secured in position so that it will not be dislodged by traffic or cleaning.

Of course, guard pipe for underground services is also necessary at the ends of the installation. Figure 3-32 shows protection at a terminal pole at the line end, and figures 3-33 and 3-34 show protection at the station end. Note that pipe covering is provided from a point approximately 12 inches below the ground surface to the protector cabinet.

If you must make an underground installation, follow the procedures as set forth in pertinent technical orders and you should have very little trouble.

Exercises (432):

1. What cable installation procedure provides cable protection from destruction from farm equipment, etc.?

2. What is the usual method for installing telephone cable?

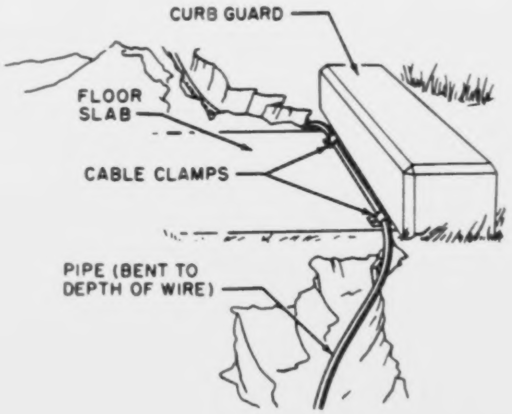


Figure 3–31. Pipe position for bridge crossing.

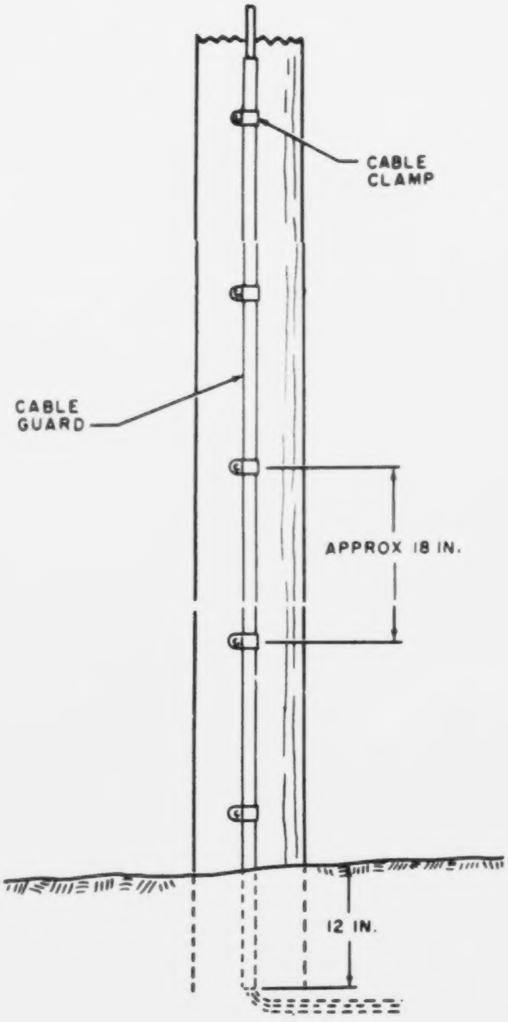


Figure 3–32. Mechanical protection for underground wire at pole.

3. Give two methods for burying cable.

4. Describe two procedures for handling telephone wire reels.

5. List the types of insulation damage to look for when placing wire into a trench.

6. To what depth (in inches) should a trench be dug before placing a telephone cable in it?

7. Identify three materials that are commonly used to protect telephone cable that can't be placed at the usual underground depth.

8. At what distance apart should cable clamps be when underground cable or wire is brought up to and installed at a pole?

9. Name two requirements for terminating cable at the station end.

3-3. Entrance Hole and Station Protector Installation Principles

After the wiring is brought to the building, the next step is to provide a place for its entry into the building. To extend the telephone wiring into the building, provide an entrance hole at a convenient location. Locate the hole to provide the shortest possible outside building run without causing inside wiring problems. Also, give some consideration to the location of the protector with respect to the entrance hole location. Since the protector may be located either inside or outside of the building and also requires a good ground, it would simplify the job of installation to locate the entrance hole and protector adjacent to an existing ground (water pipe, gas pipe, etc.). Whenever possible, select a point for the

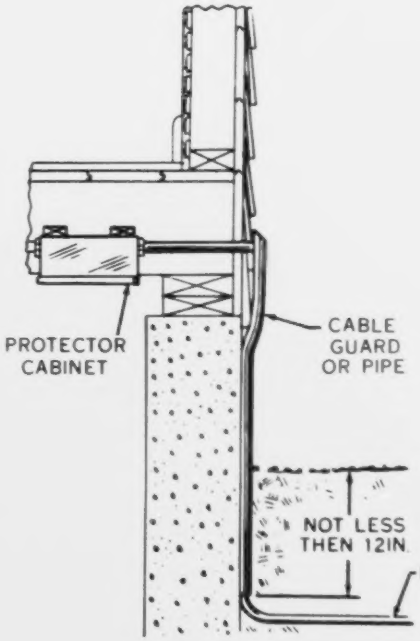


Figure 3–33. Mechanical protection for underground wire at station.

entrance hole immediately above the building foundation sill or make the entrance at a wooden frame, either a door or a window. Avoid entrance through metal frames.

433. State typical entrance hole requirements and specify procedures to use when making such a hole.

Entrance Hole. After you have determined the best location for the entrance hole, drill the hole. In general, make the hole large enough to accommodate the immediate and anticipated number of wires that will go into the building; however, do not make the hole diameter greater than one-half the width of the material through which the hole is made. Rather than make a hole with too large a diameter, drill two small holes. If an insulating tube is used, drill a hole just large enough for the tube to enter. Find the proper installation hole sizes for the various insulated tubes in the technical orders.

To help keep moisture out of the building, drill entrance holes so that they slope upward from the outside. When entering through brick walls, make the hole in a seam between the bricks. Drill from the side of the wall where you desire the appearance to be the best.

When it is necessary to locate the entrance hole at metal window frames set in concrete, drill halfway from the inside of the buildings and halfway from the outside. Start the holes so that they meet approximately 3 inches behind the visible end of the window frame.

Insulating Tubes. The entrance holes for exposed stations require the use of insulating tubes, except when service entrance conduit is used, or when the entrance hole is made entirely through brick or masonry. No tube is required in either instance.

When making the installation, at least 1/4 inch but not more than 1 inch of the tube should project beyond the surface of the wall. Cut the tube if necessary. In addition, the tube must fit snuggly in the entrance hole. If it does not, place sufficient layers of friction tape around the outside end of the tube to insure a snug fit.

Exercises (433):

1. What diameter should you make an entrance hole?

2. Give the slope requirement for an entrance hole.

3. Where must you drill when making an entrance hole in a brick wall?

4. What is a major concern for an installer when running telephone wire?

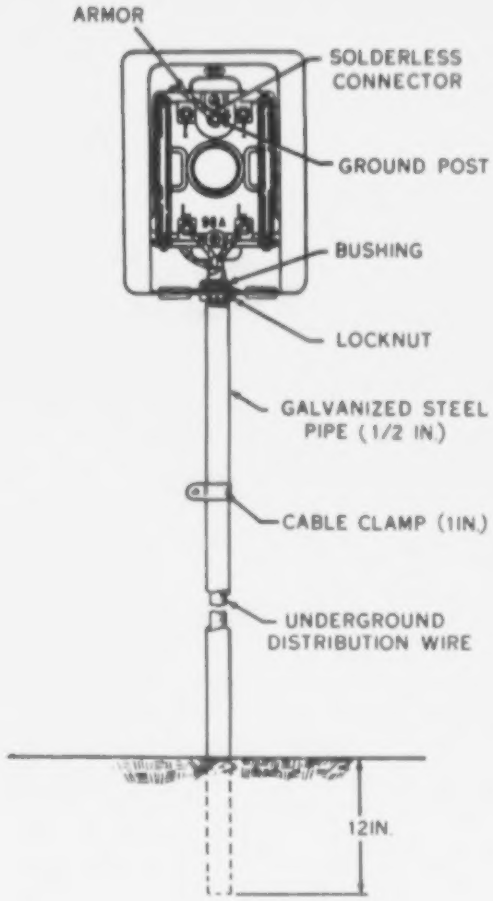


Figure 3-34. Mechanical protection at outside station protector.

5. Identify two situations where an insulating tube is not required at an entrance hole.

434. Correlate fault and protector terms with condition, distance, and wire terms.

As mentioned previously, the protector safeguards the station from excess voltages and currents. To do this, however, it must be installed correctly and must be in proper working order.

Station Protector. Improperly mounted protectors allow carbon dust to create an undesirable ground. Sometimes the heat from lightning creates an undesirable ground.

Location. Locate station protectors where they are readily accessible for inspection and maintenance and as close as possible to the entrance hole. Select a location which permits the use of a short ground wire directly connected to its grounding device. Figure 3-35 shows a typical outside protector mounting. When a protector is mounted outside, it should be placed no more than 5 feet above the ground level.

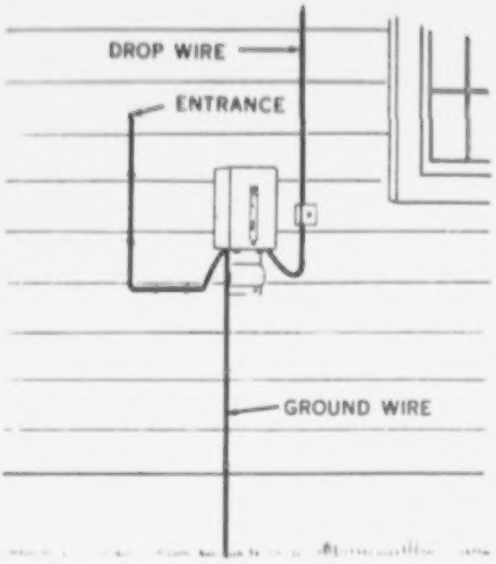


Figure 3-35. Outside protector mounting.

A clearance of 1 foot or more is required between the protector and any power installation.

Figure 3-36 shows a typical conductor arrangement for an outside protector. Note that all wiring leaves the protector at the bottom. Also note that the line wiring connects to the two lower terminals in the protector, and the station wiring connects to the two outside terminals near the top. The ground wire connects to the center terminal at the top. With an inside protector, this situation may be reversed. That is, you connect the ground wire and the station wires at the bottom of the protector and the line wires to the top. This means, of course, that you install the protector with its ground and station wire terminals at the bottom rather than at the top.

Exercises (434):

1. Match the fault and protector terms of column B with the condition, distance and wire terms that most nearly relate in column A. Use most column B terms twice.

Column A	*Column B*
____ (1) 1 foot.	a. Undesirable ground.
____ (2) 5 feet.	b. Selective location.
____ (3) Carbon dust.	c. Outside mounted.
____ (4) Short ground wire.	d. Power cable.
____ (5) Accessible.	e. Bottom exit.
____ (6) Station wiring.	f. Bottom terminals.
____ (7) Lightning.	g. Top terminals.
____ (8) Line wiring.	h. Center terminal.

435. Name devices useful for a telephone system ground, give installation specifications, and cite typical grounding rules.

If a station protector is to function properly, it must be connected to a good ground. Thus, you must connect the ground wire to the preferred ground if it is available.

Grounding of station protectors. The following is a list of suitable grounds, placed in the order of their preference:

a. The cold water pipe of a public or base water system.

b. The cold water pipe of a private water system, providing the system contains at least 10 feet of buried pipe.

c. A permanently installed metal tank, conduit, or pipe.

d. A ground rod. In dry and sandy soil and in extremely cold regions, one rod will not provide an adequate ground. In such cases, it may be necessary to use several rods strapped together. When you use several rods, allow at least 12 inches of space between them. Figure 3-37 shows two ground rods strapped together.

There are three sizes of wire available for making ground connections: Nos. 6, 12, and 14 AWG rubber- or plastic-insulated wire. Ground one fuseless protector or three fused protectors using No. 14 wire and two fuseless or five fused protectors while using No. 12 wire. You may ground any number of equipment protectors while using No. 6 wire. If a ground rod is to be used instead of other preferred grounds, use a separate rod with separate ground wiring with each protector.

Good locations are important for the ground and ground clamps which secure the ground wire. Also, you must use correct electrical procedures in making all ground wire connections. Good ground connections are just as important as good connections at other points in the circuit.

Do not place a ground rod in public alleys and streets or on the sidewalk side of a building where it could be tampered with or broken. Place it as close as possible to a basement wall, if this is possible, because the basement of a building is

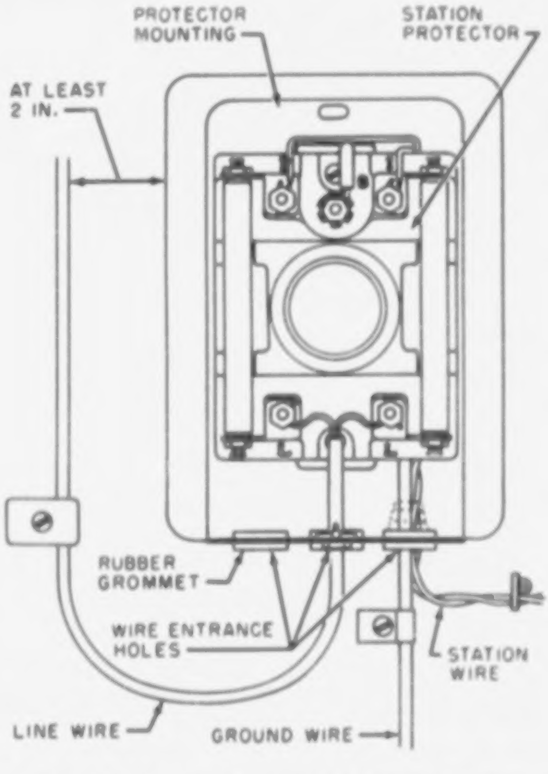


Figure 3-36. Conductor arrangement in an outside protector.

the most suitable place for ground rods. After installation, inspect the rod to make sure that the tail wire is not broken.

Several rules apply to ground wires. Never use spirals or bends less than a right or 90° angle. Also, the ground wire must be one piece. Use short sections only as straps between protectors. Use splices only between the ground wire and the tail wire of the ground rod, and between the ground wire and a common No. 6 ground wire. You must separate the instrument wiring and the protector ground wire on open runs; that is, you place inside wires under separately mounted fasteners. Do not twist inside wires and protector ground wires together. Remember, you do not place the ground wire from a protector in a ring run. Also, keep the ground wire running to the ground rod at least 6 feet from the ground rods of other services.

Exercises (435):

1. Which part of a water system may be used as a ground for a communications system?

2. Identify the grounding device that you may be required to install for a telephone system.

3. How far apart should ground rods be?

4. Identify the wire sizes commonly used with communications system ground rods.

5. What AWG wire(s) must be used when providing the ground connections for two fuseless protectors to the same ground rods?

6. What is the preferred place for a ground rod?

7. Give the ground wire rule regarding spiraling or bending.

8. State the ground wire rule regarding short sections.

9. Give the ground wire rule regarding wire separation.

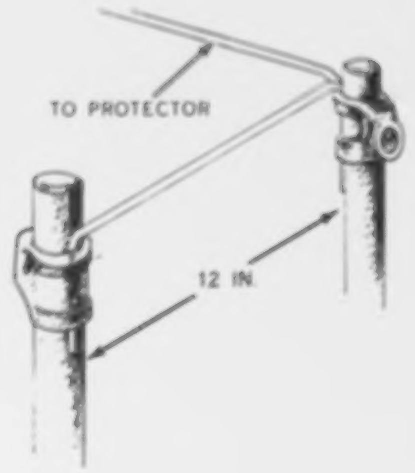


Figure 3-37. Probable connection for two installed ground rods.

3-4. Inside Wire Planning and Installation

As an installer-specialist, you must carefully plan the installation of inside wiring. To do this, you must consider the particular building arrangement as well as the needs of the personnel or organization occupying the building. Since very few buildings are exactly alike and the telephone requirements in different organizations are seldom the same, it is evident you must tailor an inside installation to the specific situation.

Your first steps in planning an effective installation are selecting the telephone location and insuring a good wire appearance. In the following paragraphs, you will learn the criteria and methods you should consider in such planning.

Consider at the beginning the type of inside wire, the wire fasteners, the lead in, and any special job requirement. In other words, plan the inside wire job at the time you plan the drop wire run and select the point of entrance.

436. Cite example telephone location requirements.

Telephone Location. First, let's consider the telephone location, which should meet the following requirements: A user should be able to hear the bell clearly within an area of reasonable size surrounding the telephone location; the telephone should be in a dry place; it should not be near a grounded metallic object, such as a radiator or sink, and never located near any electrical appliance. If you cannot separate the telephone from metallic objects, shorten the handset cord so that users cannot contact the metallic object or electrical applicance when using the telephone. Locate dial sets where there is sufficient light at all times. Also, place the telephone set in a location where it is accessible for inspection and repair and free from excessive vibration. Frequently, you must mount wall sets on a backboard. If a combined set is to be used, you can usually put it on the desk. That is, you need not consider a backboard (for the wall set) or a bell box (for the desk set) when you use a combined set.

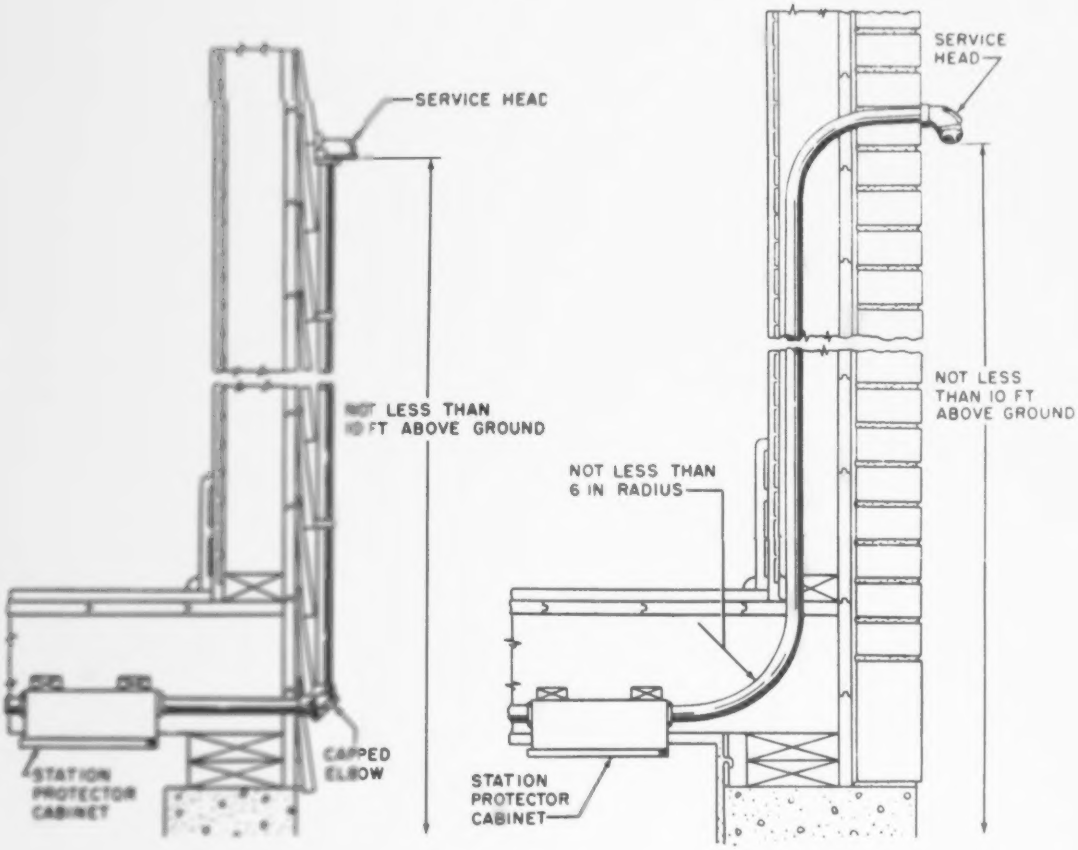

SERVICE HEAD
NOT LESS THAN 10 FT ABOVE GROUND
CAPPED ELBOW
STATION PROTECTOR CABINET
SERVICE HEAD
NOT LESS THAN 10 FT ABOVE GROUND
NOT LESS THAN 6 IN RADIUS
STATION PROTECTOR CABINET

Figure 3-38. Typical service conduit where protector cabinet is inside building.

Exercise (436):

1. Match the telephone system units of column B with the location requirements of column A. All units will be used more than once.

Column A

___ (1) Free from vibration.
___ (2) Support unit.
___ (3) Separate from ground.
___ (4) Accessible for inspection.
___ (5) Audible.
___ (6) Accessible for repair.
___ (7) Needs light.

Column B

a. Telephone bell.
b. Handset cord.
c. Dial set.
d. Wall set.
e. Backboard.

437. Give typical requirements for a service conduit installation.

Conduit. When service conduit is provided, use it for the telephone wire building entrance whenever practicable. To determine if a service conduit is available, you must survey the premises. You should also note during this survey the most advantageous routing of the interior and exterior wire runs.

Figures 3-38 and 3-39 show that the service head of a typical conduit must be not less than 10 feet above the ground. Figure 3-38 also shows that the station protector has been installed inside the building. The conduit out of that protector cabinet must have a radius at the bend that is not less than 6 inches. Figure 3-39 shows a protector installed outside the building. The cabinet for this protector is shown to be 6 feet above ground. Also, note the conduit for the ground wire in this latter illustration.

Exercises (437):

1. What is the minimum distance above ground that a conduit service head is to be located?

2. What is the minimum turn radius for a telephone system conduit?

3. Identify a common method used when connecting the ground wire to a telephone system conduit.

438. Specify wiring factors, rules, and clearances to be applied to inside wire runs.

Wire Run. Location and appearance are two factors that determine the wire run. For example, locations where severe moisture conditions may cause wire trouble, such as the area under the building, require that you use a moisture-resistant wire. You may also use this wire as a substitute for bridle wire. If appearance is very important, use a wire built for appearance, one having a jacket that blends with woodwork or desk coloring. Ivory-jacketed wire is available for light-colored woodwork and brown-jacketed wire for mahogany or walnut installations.

Routing. In every situation do the best job of which you're capable. Since a concealed wire run will eliminate most appearance problems and some maintenance problems, you may frequently select this type of route. In selecting and using a concealed wire route, you need a working knowledge of building spaces. For example, frame buildings generally have air spaces between the inside wall.

For examples of concealed wiring back of building walls, refer to figures 3-40 and 3-41. Figure 3-40 shows concealed wiring in frame construction, and figure 3-41 illustrates concealed wiring in masonry construction. Fish the telephone wire through those spaces where bad appearance or wire damage is probable. Your installation will be faster if you follow a molding or baseboard. Figure 3-42 shows a neat wire run concealed for only a short distance. Note in this illustration that the wiring is concealed back of the wall from the molding down to the subset. Note also that the exposed wiring follows the molding along the wall.

The inside wire run should follow a reasonably direct path from the point where the wire enters the building to the instrument location and should be free from obstructions. If, by selecting a longer route, you can avoid a concentration of pipes, electrical equipment, or moisture areas which would be damaging to the wire, then by all means do so. That is, select conditions where minimum maintenance will be needed and satisfactory service life will be increased. These should be the deciding factors and are of more consequence than the length of the wire run.

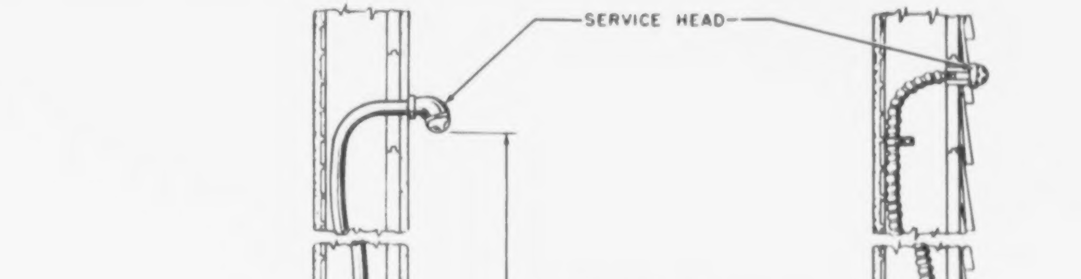

SERVICE HEAD
CABINET FOR STATION PROTECTOR
NOT LESS THAN 10 FT ABOVE GROUND
CONDUIT FITTING FOR GROUND CONNECTION TO WATER PIPE
6 FT ABOVE GROUND
CONDUIT FOR GROUND WIRE RUN TO GROUND ROD

Figure 3-39. Typical service conduit where protector cabinet is outside building.

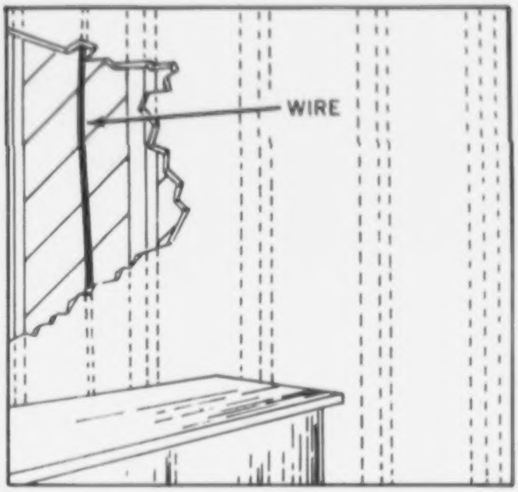


Figure 3–40. Concealed wire run for frame construction.

Rules for wire runs. Many Air Force installations are not suitable for concealed wire; therefore, you must usually make surface wire runs. Following are several rules that apply for surface runs:

a. Follow the baseboard rather than the ceiling line except in a basement.

b. Use wire molding, picture moldings, or raceways when they are available.

c. To prevent damage, place the wire in a metal or wood molding on vertical runs where picture or door moldings are not accessible.

d. Be sure that the inside wire does not interfere with the operation of windows or doors and that the wire run does not span stair wells or other open places.

e. Do not make beam-to-beam runs above workbenches or stored boxes unless you can place the wire where it will not be damaged.

f. If joists must be spanned, stay within 3 inches of the wall.

Molding wiring. For an example of wiring in a molding groove, refer to figure 3-43. As shown in this illustration, the wiring enters an upstairs room at a molding near the ceiling. It follows this molding to a position across the room where it goes behind of the wall and down to a lower molding. It then follows this lower molding to a position where it can be connected to a subset. In addition, note that there is an alternate wire exit shown for the connection of a wall-mounted set.

Exercises (438):

1. What is the factor being considered when you're studying an area for dryness?

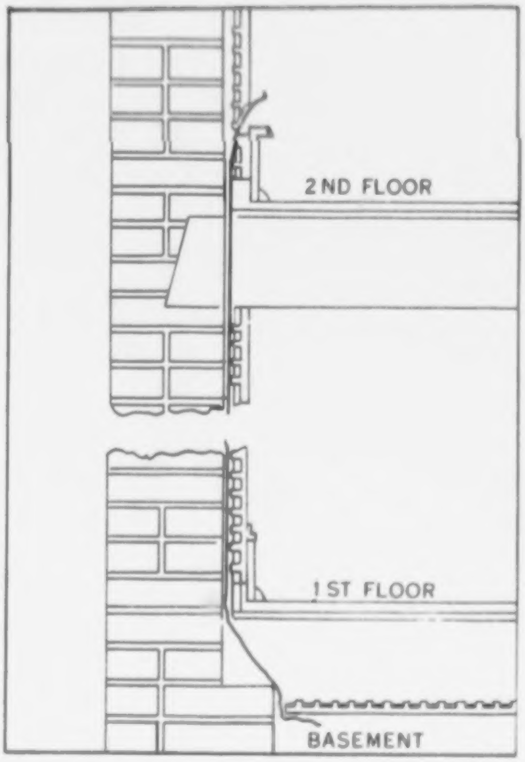


Figure 3–41. Concealed wire run for masonry construction.

2. What factor are you considering when taking note of obstructions?

3. Cite the surface run rule for vertical wire placement.

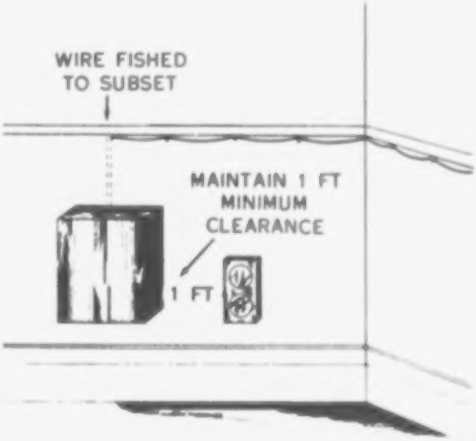


Figure 3–42. Partially concealed wire run.

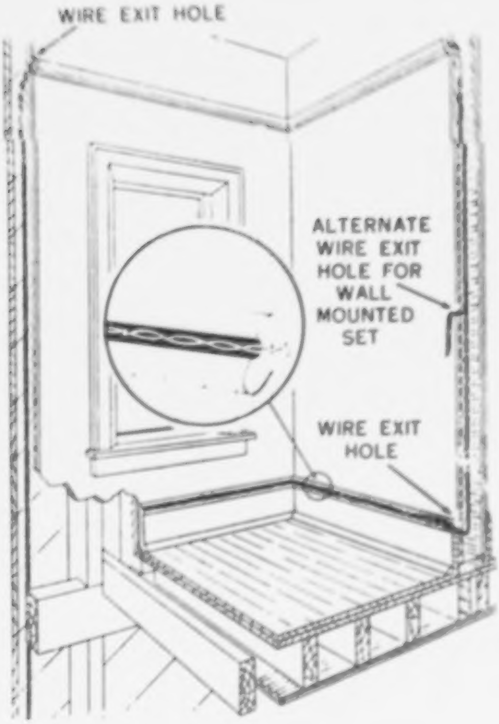

WIRE EXIT HOLE
ALTERNATE WIRE EXIT HOLE FOR WALL MOUNTED SET
WIRE EXIT HOLE

Figure 3-43. Wire run in molding groove.

4. Give the major rule for placement of a telephone wire.

5. What distance should there be between the telephone instrument and an electrical receptacle?

6. At a joint, what is the preferred distance for the wire to be from the wall?

439. Identify example wire fasteners and give a safety precaution to practice when installing wires.

Wiring hardware. Wire installation techniques depend upon the job situation. Throughout the wire run, wire must have the proper clearance and protection. If wire is secured to walls or goes through walls, floors, or ceilings, you must use proper fasteners and prescribed protection methods. The fasteners for inside wire are designed to fit almost all situations which you will encounter. Always place the fasteners over studding in the walls and never to fasten wires directly to conduits, pipes, or their supports. Figure 3-44 illustrates some of the wire attachments used in basements, storerooms, and other areas where appearance is secondary.

In finished rooms and offices, use discrete cable clamps employing fasteners suitable for the wall surface supporting the wire run. In many instances, you'll use various types of staples in the attachment of inside wiring, including some which are applied with staple guns.

Exercises (439):

1. Using figure 3-44, identify the two inside telephone wire fasteners illustrated.

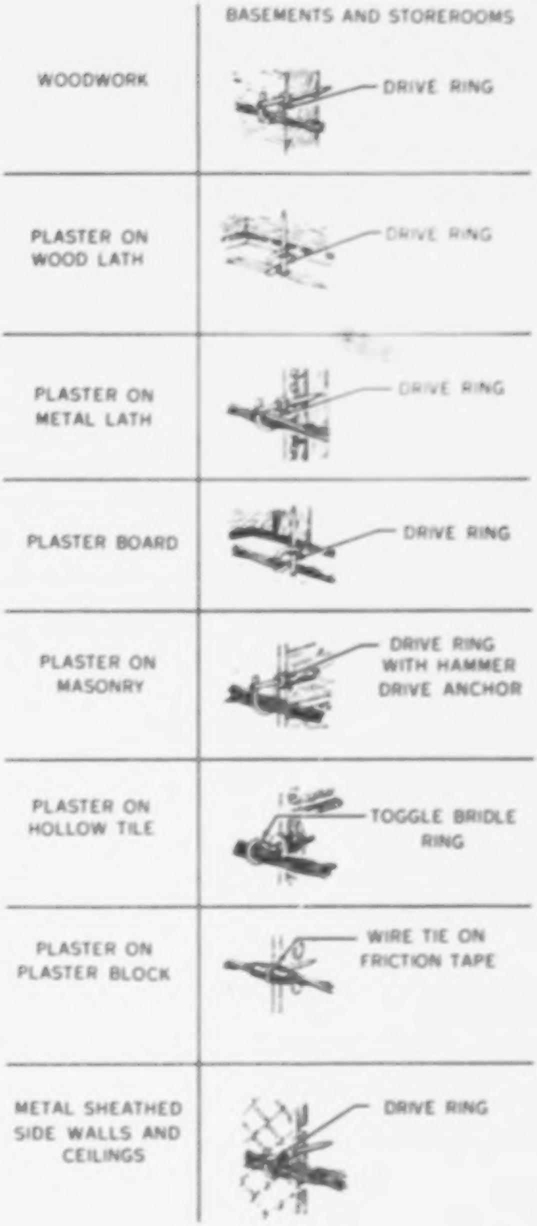

BASEMENTS AND STOREROOMS
WOODWORK
DRIVE RING
PLASTER ON WOOD LATH
DRIVE RING
PLASTER ON METAL LATH
DRIVE RING
PLASTER BOARD
DRIVE RING
PLASTER ON MASONRY
DRIVE RING WITH HAMMER DRIVE ANCHOR
PLASTER ON HOLLOW TILE
TOGGLE BRIDLE RING
PLASTER ON PLASTER BLOCK
WIRE TIE ON FRICTION TAPE
METAL SHEATHED SIDE WALLS AND CEILINGS
DRIVE RING

Figure 3-44. Typical station wire attachments.

2. Identify two additional wire fasteners not mentioned in exercise 1.

3. State a safety precaution to practice when installing inside wires.

440. Distinguish between requirements, precautions, and procedures for installing inside wiring protection.

Wiring protection. Select the protection for inside wiring (tape wrappings, porcelain tubes, woven conduits, etc.) to suit the job at hand. Figure 3-45 shows examples of protection applied in various situations. Use woven conduit when shaping of the protective conduit is required, as when the wire crosses a pipe or beam. Note the methods used to prevent slipping. Use porcelain tubes when crossing exposed steam pipes or open electric wires. Whenever practicable, place a wire run above rather than below any water pipe which must be crossed. Water pipes may sweat under certain conditions. Keep at least 6 inches clearance between telephone wiring and foreign ground wires; however, since you cannot always do so, use the protection illustrated where you cannot separate the wire from other objects at the proper distance.

Remember that between the point of entrance and the inside-mounted protector, the line wire must not touch nor be capable of moving into a permanent contact with any combustible or electric current-conducting material.

Conduit. You will frequently use conduit in Air Force buildings for telephone wiring; hence you must understand conduit arrangements and know how to run wire in conduit. First, let us consider conduit in general.

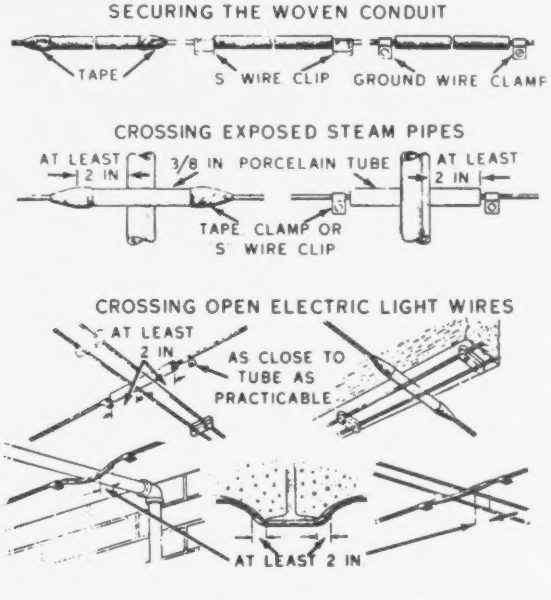


Figure 3-45. Insulating protection for wire.

Develop the conduit system with its primary purpose in mind: to inclose and support the building cables and wiring. Therefore, even if the characteristics of a building indicate the need for a conduit system, do not complete the details until you have determined the required locations, quantity and type of service.

Building conduit systems not only eliminate the hazards, exposure to damage, and objectionable appearance of unconcealed cable and wiring, but also facilitate the installation of the access to the building cable plant. Thus, future changes in the location and number of telephones are less difficult. Because of these characteristics, conduit systems are particularly desirable for buildings having a large number of telephones. Regardless of the service requirements, however, install conduit in buildings or areas where:

a. Exposed cable and wire would be subjected to mechanical or electrical damage.

b. Exposed cable and wire would constitute a hazard.

c. The appearance of exposed cable and wire would be objectionable.

The above-mentioned characteristics may apply to all or part of a building; therefore, you will determine the need for conduit for each area of a building, rather than for the building as a whole. Some buildings are designed and constructed for organizations of known size and activity and are established by building type, provided the building is used as planned.

If conduit is to be concealed, install it before the building is completed. Although you may place some conduit after the building is finished or during remodeling, it is more expensive to install and very difficult to conceal. Furthermore, a conduit system added to a completed building may not be as effective as one that is planned and constructed as an integral part of the building. So installation of efficient and economical conduit systems demands the complete coordination of all agencies concerned with construction of the building.

Exercises (440):

In the blank before each statement place an R if the statement is a requirement, a P if the statement is a precaution, and an S if the statement is a procedure.

____ 1. Use protective conduit for crossover wire.

____ 2. Install telephone wires above a water pipe.

____ 3. Insure 6 inches between telephone and ground wires.

____ 4. Separate line wires from power cable.

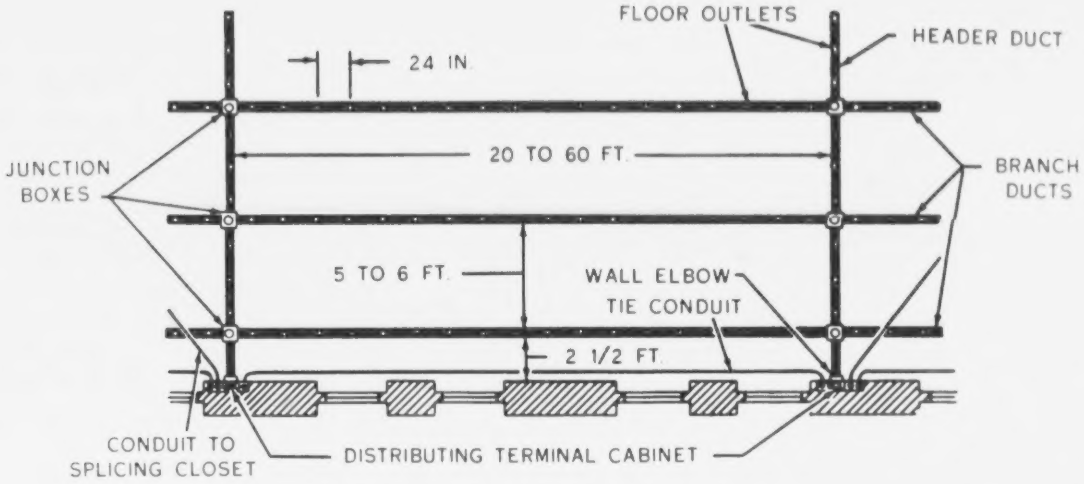


Figure 3-46. Gridwork underfloor duct.

____ 5. Install conduit around exposed cable.

____ 6. Install conduit before building completion.

441. Correlate types and features of conduit systems with typical applications.

Conduit systems. There are four general types of building conduit systems: underfloor duct, conduit underfloor-from-wall, base raceway, and molding raceway. These systems protect the conductors from mechanical injury and provide easy access for installation of wiring and connections. They also conceal conductors when exposure would constitute a hazard.

Underfloor duct systems are of two kinds—gridwork and cellular steel floor. The gridwork system, shown in figure 3-46, is made up of parallel header ducts running from distribution terminal cabinets. Space parallel ducts from 20 to 60 feet apart and branch ducts 5 to 6 feet apart, run at right angles to the header ducts. Position junction boxes at the intersections of the header and branch ducts. Space floor outlets with removable caps about every 24 inches along the duct runs. Use separate conduit to carry tie cables between distributing terminal cabinets and splicing closets.

In the cellular steel floor system, shown in figure 3-47, the cells or ducts in the floor serve as wiring channels. These ducts are placed on 6-inch centers. Usually, you assign specified ducts to the in-between ducts. Thus, you have access to ducts spaced at 12-inch intervals across the floor. You may install outlet heads at practically any point along the duct runs. Cross these parallel cells with header ducts which run to distribution terminal cabinets. Provide junction boxes in the header ducts.

The conduit underfloor-from-wall system, as the name implies, is a network of conduit extending from distribution terminal cabinets to outlet boxes in the walls, columns, or floors of a building. Figure 3-48 illustrates a typical underfloor-from-wall system. Note how the conduit extends underfloor from a distributing terminal to various locations in the building.

Base raceway systems may be either metal or wood. Metal raceways are merely wall baseboards that contain channels through which wire can be run (see fig. 3-49).

Outlets are provided at intervals along the faceplate of these baseboards. Wooden raceways are also wall baseboards but with a space in the rear through which you run the wire (see fig. 3-50.) A slot between the wood baseboard and the baseboard molding is used for outlets. Conduit from distribution terminals to boxes mounted in the walls behind the base raceways is used with both the wooden and metal raceway systems.

Molding raceway systems are similar to base raceway systems except that you distribute the wires through concealed channels at the rear of ceiling moldings.

Placing wire run in conduit. When you are required to make station wire runs in buildings equipped with some type of conduit system, trace out the duct runs and locate the outlets which are best suited for your purpose. After this has been done, use the simplest and most direct route for the wire run.

NOTE: Make certain that the telephone wires are not placed in the same ducts with wires from other services such as power, intercommunications systems, or electrical light wires.

Usually you'll place station wiring directly in raceway-type building conduit systems. In underfloor systems, use a fishline or tape to pull wires through the conduit. If a fish tape is not available and there are no sharp bends in the duct run, a length of galvanized steel wire is a

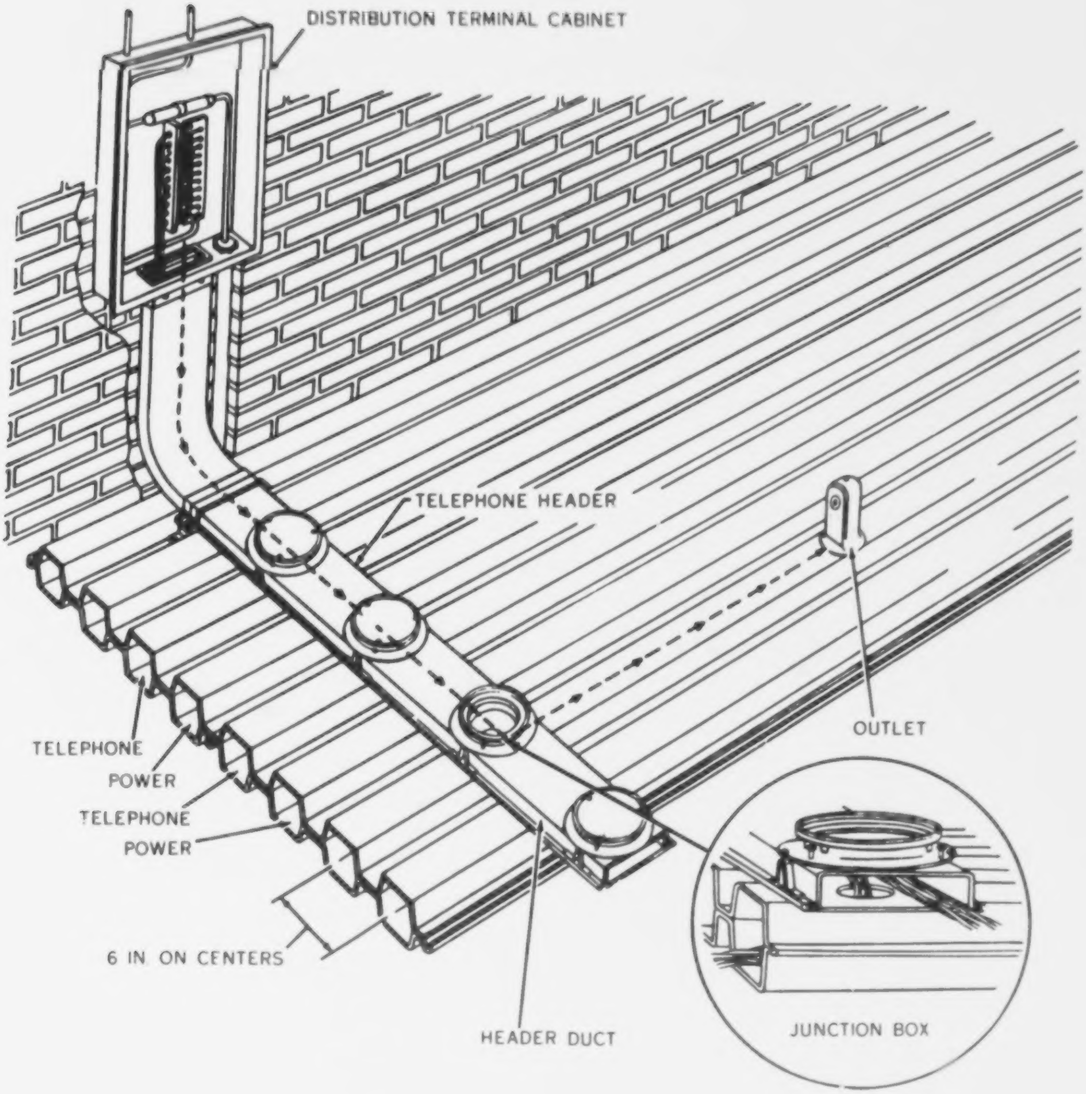

DISTRIBUTION TERMINAL CABINET
TELEPHONE HEADER
OUTLET
TELEPHONE
POWER
TELEPHONE
POWER
6 IN. ON CENTERS
HEADER DUCT
JUNCTION BOX

Figure 3–47. Cellular steel floor type, underfloor duct.

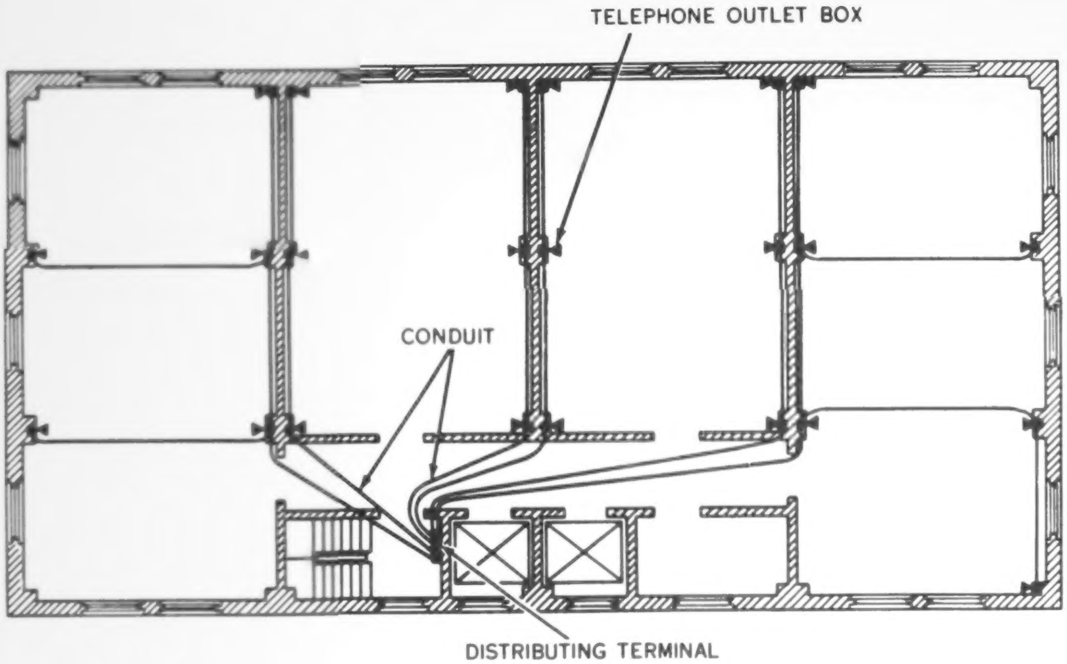

TELEPHONE OUTLET BOX
CONDUIT
DISTRIBUTING TERMINAL

Figure 3–48. Conduit underfloor from walls.

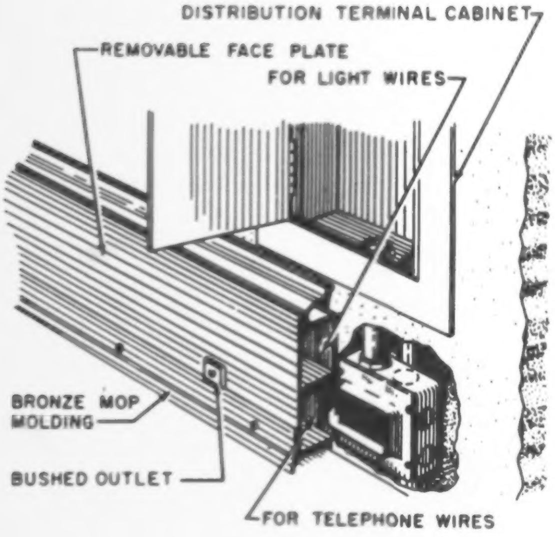

DISTRIBUTION TERMINAL CABINET
REMOVABLE FACE PLATE
FOR LIGHT WIRES
BRONZE MOP MOLDING
BUSHED OUTLET
FOR TELEPHONE WIRES

Figure 3–49. Metal base raceway.

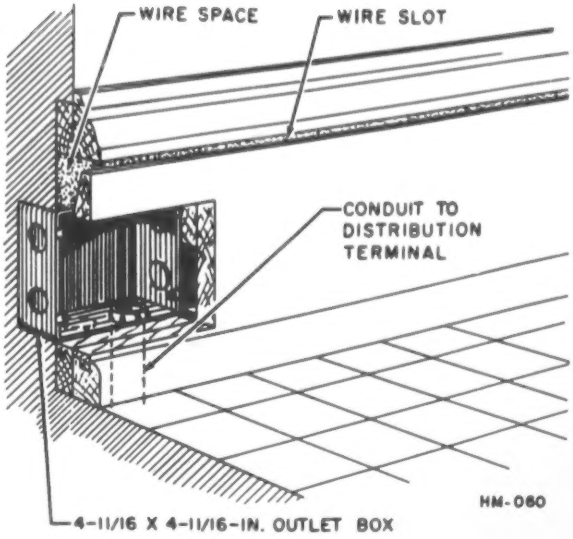

WIRE SPACE
WIRE SLOT
CONDUIT TO DISTRIBUTION TERMINAL
HM-060
4-11/16 X 4-11/16-IN. OUTLET BOX

Figure 3–50. Wood base raceway.

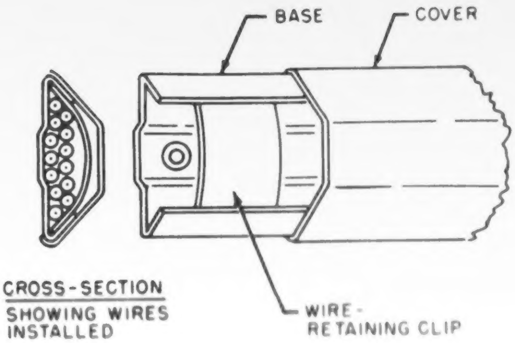


Figure 3-51. Metal overfloor duct.

good substitute. In either case, first push the fish tape or wire through the conduit; then attach the station wire to it and draw it into place by removing the fish tape or wire. If the wire is hard to pull in the conduit because of the length of the run or bends in the duct, lubricate the wire with Flax-soap or Carbowax. Only a thin film of lubricant is necessary. Excess amounts, if left in the ducts, will become gummy and tend to clog the ducts.

NOTE: Do not use a lubricant on textile-covered wires or cables and never use a mineral oil product as it may make the insulation material deteriorate.

Exercises (441):

1. Place the letter for the conduit system of column B that best relates to the factor of column 4 in the applicable blank. Each system will be used more than once.

Column A

____ (1) 5-6 feet separation.
____ (2) Wiring channels.
____ (3) Distribution cabinet to splicing closet.
____ (4) Distribution cabinet to outlet boxes.
____ (5) 24-inch spacing.
____ (6) 12-inch spacing.
____ (7) 20-60 foot spacing.
____ (8) Baseboards.
____ (9) Gridwork and cellular.
____ (10) Fishline or tape.
____ (11) 6-inch centers.
____ (12) Parallel header ducts.
____ (13) Wire isolation.
____ (14) Parallel branch ducts.
____ (15) Direct placement and routing.
____ (16) Metal and wood.
____ (17) Moldings.

Column B

a. Underfloor duct.
b. Gridwork.
c. Cellular steel floor.
d. Underfloor-from-wall.
e. Base raceway.
f. Molding raceway.

442. Name the type of overfloor ducts and cite typical methods of installation.

Overfloor Duct Installation. The conduit installed is largely determined by the conduit type. To illustrate, underfloor conduit is provided when the installation is to be made before the building construction is complete. Overfloor duct systems are provided when the installation is requested for a completed building. You may use either metal or rubber overfloor duct depending on the floor surface. The following paragraphs describe metal and rubber overfloor duct and discuss the uses and installation of each type.

Metal overfloor duct (fig. 3-51) consists of a base with sloping sides and a snap-fit cover and is available in two sizes, each in 5-foot lengths. The smaller size will accommodate five pairs of four triple-plastic-jacketed station wires; the larger size will accommodate two 26-pair inside wiring cables. Two fiber wire-retaining clips are furnished with each length.

Fittings equipped with triple twistouts provide any necessary outlets, elbows, and junctions in the duct run. Removal of the smallest twistout provides the proper size opening in the fitting for the insertion of the smaller size metal duct; removal of all three twistouts provides a large enough opening for the larger size metal duct. Use one duct under the desk to run the cable or wire up through the extension outlet by the use of a service fitting. Figure 3-52,B, illustrates a large service fitting which is used when a number of wires or cables are involved. Use the elbow adapter, shown in detail C of figure 3-52, when it is necessary to run wires up a wall.

Use metal overfloor duct on rough floor surfaces where holes in the flooring for the fastening devices are not objectionable and where secure fastening to the floor surface is desirable. For example, install small size duct as follows:

a. Run the base of the duct along the desired wire route. Connect the duct to the proper fittings by inserting it in the tongues provided in the bases of the fittings. If the length of the duct run exceeds 5 feet, add additional unit lengths of duct as required. When necessary, cut the duct to proper length with a fine-tooth hacksaw blade and smooth the cut edges with a file. For better rigidity, arrange adjoining lengths of duct so that the joint of the duct caps is separated from that of the duct bases (fig. 3-53).

b. Fasten the base to the floor with wood screws, wood screws in screw anchors, or hammer drive anchors, your choice depending on the type of flooring. Also, if the floor or baseboard is uneven and an elbow adapter does not fit snugly, secure the top portion of the adapter to the baseboard with a No. 8 roundhead wood screw, as shown in figure 3-54. Drill a hole for the screw in the centerline of the fitting about 1 inch from the top.

Exercises (442):

1. Of what material are overfloor ducts made?

2. What duct is used on rough floors?

3. Which size duct should be used when installing inside wiring cables?

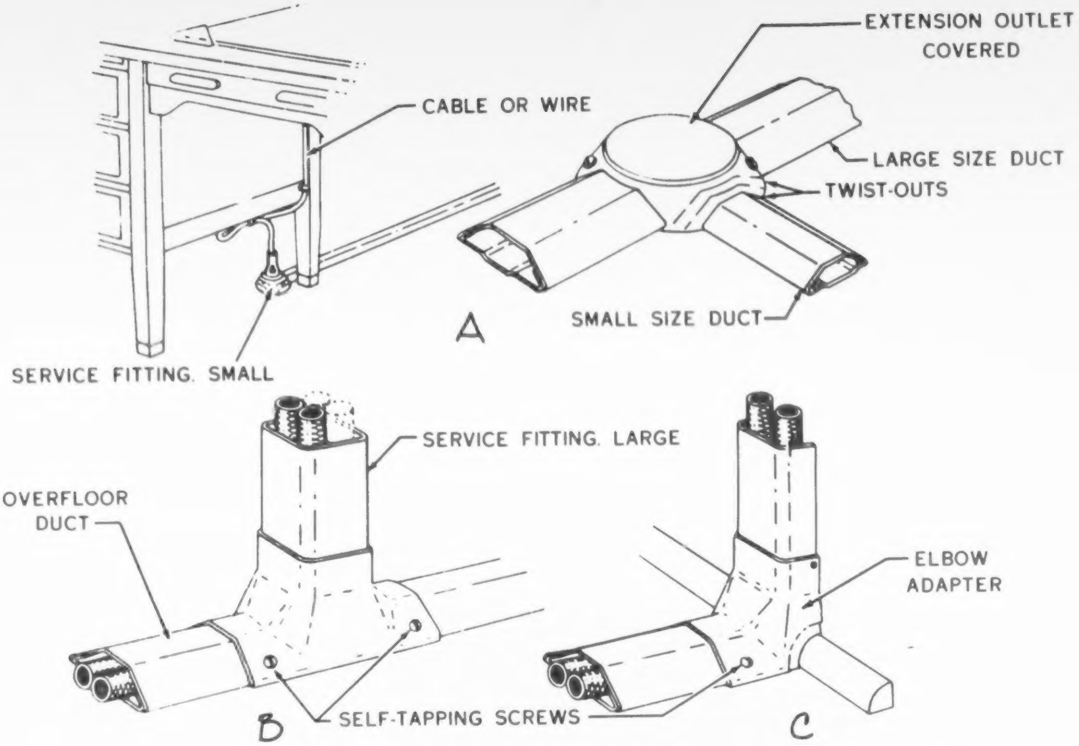

EXTENSION OUTLET COVERED
CABLE OR WIRE
LARGE SIZE DUCT
TWIST-OUTS
SMALL SIZE DUCT
A
SERVICE FITTING, SMALL
SERVICE FITTING, LARGE
OVERFLOOR DUCT
ELBOW ADAPTER
SELF-TAPPING SCREWS
B
C

Figure 3–52. Metal overfloor duct fittings.

4. What action will you take to provide an opening in the duct?

5. How do you insure a stable duct installation?

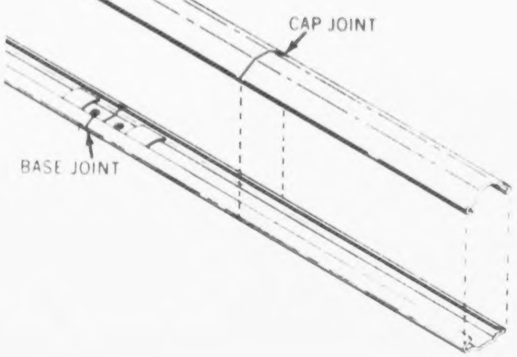

CAP JOINT
BASE JOINT

Figure 3–53. Staggered arrangement of duct joints.

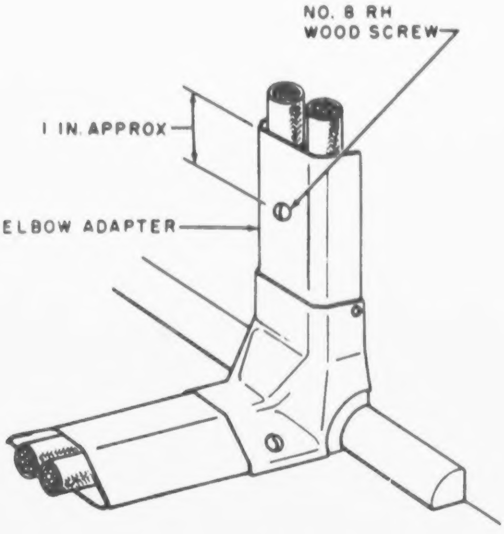

NO. 8 RH WOOD SCREW
1 IN. APPROX
ELBOW ADAPTER

Figure 3–54. Securing overfloor duct elbow adapter.

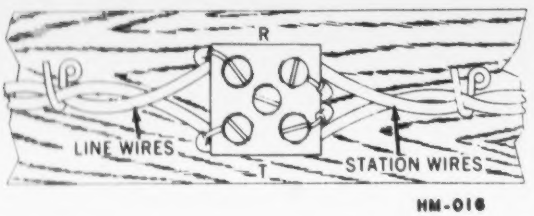


Figure 3-55. Wiring at connector blocks.

443. Identify units at which station wiring is terminated, and specify typical terminating principles or procedures.

Station Wiring Termination. Once the station wiring is complete, all that remains to be done in the building is to make the necessary connections. Generally, you terminate the station wiring at protectors, connecting blocks, or distribution terminals. Information about the use and connection of protectors was given earlier in this chapter. Therefore, let us now consider connecting blocks.

Connecting blocks. Connecting blocks are normally used in three different ways:

(1) To terminate (connect) the line and station wires near the building entrance when a protector is not required.

(2) To bridge station wiring.

(3) To connect station wiring and telephone cords.

Connecting blocks may be located on desks, tables, baseboards, beams, windows, and door frames in a substation installation. Since you must avoid door splices in the installation, the connecting block is doubly necessary. Select the location of the connecting block, like that of other portions of the installation, for accessibility and safety. Place the connecting block where neither it nor the wiring which runs to it will be a source of trouble.

In figure 3-55 you see a simple type of connecting block used to connect the line and station wires as noted in the paragraph above. Be careful when connecting the wires so that they are tip to tip and ring to ring.

When the telephone is on a desk, you frequently will mount a connecting block (similar to the one shown in fig. 3-56) on the desk with the telephone cord brought out through a slot or hole in the desk top and within a few inches of the front of the desk. If this arrangement is not possible, mount the connecting block on the side of the desk. The type 42 block, shown with the cover removed, indicates the means by which wires are brought into the connecting block. Notice that the station wire is wound around the block so that a strain on the wire will not pull it loose from its terminal. Also, the telephone cord coming into the connecting block is arranged so that a strain will not loosen the connection. While observing figure 3-56, you should also note that the block terminals are identified by the letters "R," "G," "B," and "Y." These letters are used to identify the terminals for the connection of station and cord wiring. Normally, these letters signify the colors of red, green, black, and yellow. The ring and tip leads are usually connected to the R and G terminals on the block. However, to terminate any telephone equipment and insure proper operation, you must connect it in accordance with the color code and the circuit diagrams for the piece of apparatus concerned.

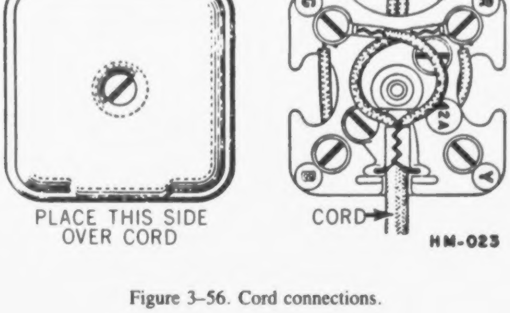


Figure 3-56. Cord connections.

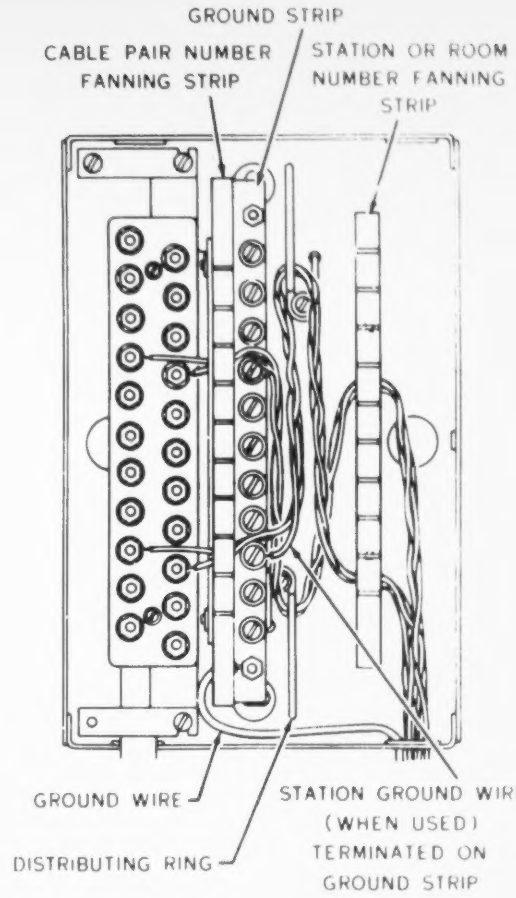

GROUND STRIP
CABLE PAIR NUMBER FANNING STRIP
STATION OR ROOM NUMBER FANNING STRIP
GROUND WIRE
DISTRIBUTING RING
STATION GROUND WIRE (WHEN USED) TERMINATED ON GROUND STRIP

Figure 3-57. Typical distribution terminal.

Distribution terminal. In buildings where a large number of telephones are installed, such as offices, apartment houses, etc., distribution terminals are often used for terminating the inside cables. This type of terminal arrangement is illustrated in figure 3-57. While observing this type of terminal, note that fanning strips are provided for cable pair identification and for the identification of phone wires by either station or room numbers. Also note that a ground strip is included which provides a ground terminal for each phone in the building.

When a distribution terminal is provided, you will find it advantageous to connect the station wiring directly to the terminal. When such connections are made, you should leave enough slack in the wire so that it can be terminated at any binding posts in the terminals. This wiring arrangement is usually accomplished by routing the wire through the distributing ring farthest from the assigned set of binding posts, as shown in figure 3-57.

Exercises (443):

1. What terminating device enables you to interconnect the station inside wiring and the telephone cord?

2. What terminating device has many pairs of terminals for the attachment of a large number of telephone inside cable pairs?

3. Cite two factors to be considered when preparing to install a connecting block.

4. Give an important precaution for terminating line and station wires at a connecting block.

5. What action do you take to protect a station wire from pulling away from the connecting block terminal?

6. State two requirements for the termination of station wires at a distribution terminal.

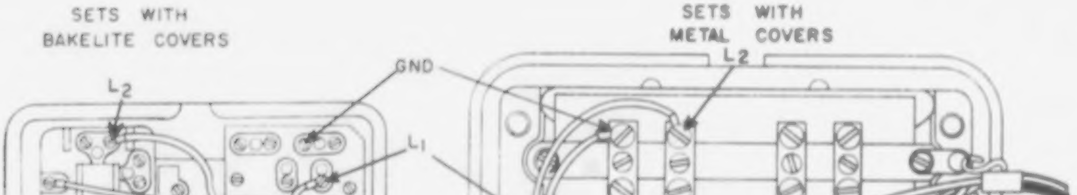


Figure 3-58. Example of subset wiring.

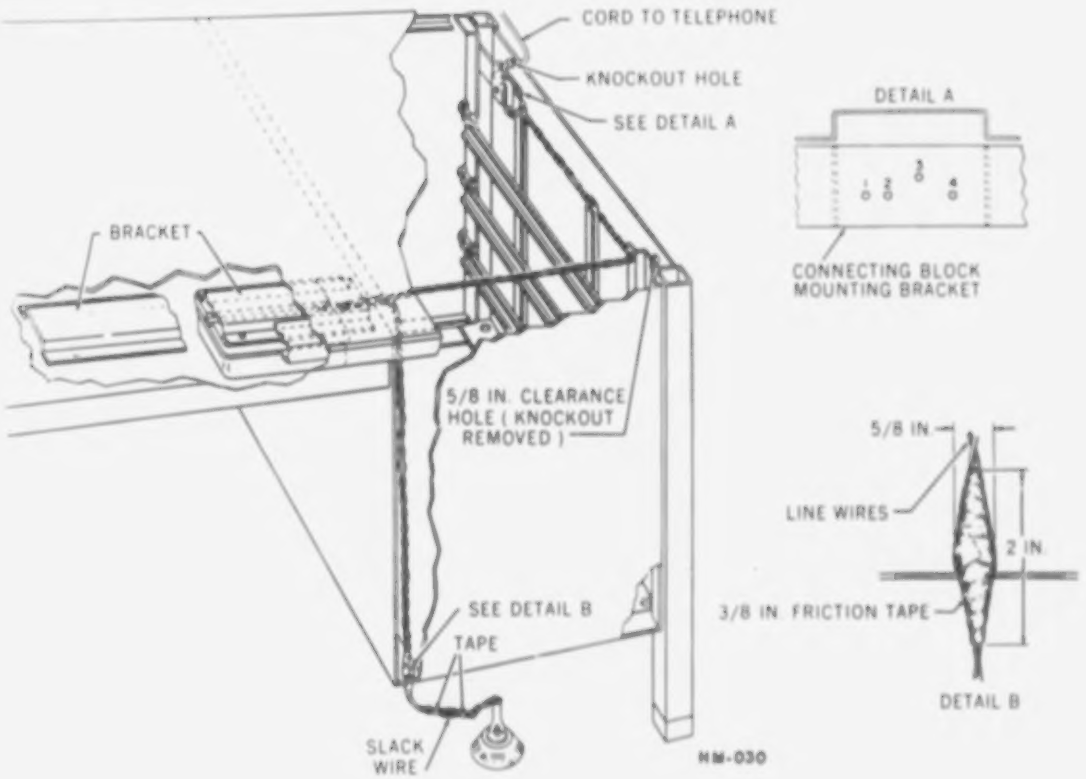


Figure 3-59. Typical wiring facilities for desk.

444. Identify auxiliary telephone station equipment and give typical requirements for station apparatus installation.

Station Apparatus. After the station wiring is installed and terminated, you then are ready to connect the telephone set and any other auxiliary equipment. Auxiliary telephone devices such as signaling equipment, switching keys, etc., are normally called station apparatus.

Subsets. Combined subsets are the easiest items to install because, in most cases, it is only necessary to connect the proper wires to the proper terminals. Wire fasteners are not required if you place the subset where no strain will be placed on the conductors, or if you conceal the wire as it comes to the subset. Remember, connect the cord connections and the inside wire conductors together at the terminals of a connecting block mounted on the desk, wall, etc. Connect each telephone to the line in accordance with the specific wiring diagram instructions furnished by the manufacturer. Figure 3-58 shows terminations of the hand set cord and the line within two subsets.

Desk type telephone. In most cases, it is not good practice to attach wiring to desks. In situations where it cannot be avoided, you should allow at least 1 foot of slack wire between the floor outlet or last wall attachment and the first desk attachment. This wiring arrangement allows you to move the desk slightly without damaging the wire. If a connecting block must be mounted on the desk and the desk panel is less than 3/8 inch thick, build the panel up with a wooden backboard to increase its strength. A wire run on a desk must be neatly installed and concealed as much as possible. If it cannot be concealed, be sure that it is neat because everyone notices a sloppy wire run. To help provide concealment, place the wire in the angle formed by the top and sides of the desk or in the angle formed by the legs and panels of the desk. You should use inside wiring nails or staples for attaching wire to the desk.

Some types of desks are equipped with wiring facilities. On metal desks equipped with wire runs, protect the wire at the entrance and exit holes by installing the soft, rubber grommets provided or by placing several wrappings of tape on the wire. Figure 3-59 illustrates the wiring arrangement on a desk equipped with wiring facilities.

Signaling equipment. In the installation of telephone equipment, you may come across situations where normal station ringers do not meet the signaling needs of the buzzers. In installations where noise makes it difficult to hear the telephone ring, it may be necessary to install such apparatus as extension ringers, loud-ringing bells, buzzers, or lamp indicators.

Extension ringers increase the utility of the telephone by increasing the area over which a telephone call can be announced. In a shop area a loud-ringing bell is generally used for the extension ringer (see fig. 3-60). Various types of these bells are used—some operating on normal ringing current and others through a system of relays on alternating current at 110 volts. Select the bell for the particular installation to fit the conditions of the area. Properly locating the bell will insure maximum efficiency.

Connection, in most cases, is a matter of bridging the bell across the ringer of a subset or, if the bell is equipped with an internal condenser, of connecting the bell directly across the line. When connecting extension ringers, that you remember must include a condenser in the circuit by one of the two means mentioned. In any case, you must connect the extension ringer or bell in accordance with the instructions furnished with the unit.

As an installer, you must be familiar with the way ringer bells operate so that you can make any necessary adjustments. To acquaint you better with ringer bells and ringer systems, let us briefly review ringer operation. Having completed Chapter 2 in Volume 2 of this course, you know the operating principles and can recognize many of the bell features shown in figure 3-61. The ringer has two coils of wire, each wound on an iron core with an armature pivoted above one end of a permanent magnet. The creation of a magnetic field, which causes the armature to move from one pole to the other, operates the ringer. When an electric current is passed through the ringer windings, one end of the armature is pulled by the current (if the polarity is right) in the same direction as by the permanent magnet. Since unlike poles attract and like poles repel, the left end of the armature in figure 3-61 is attracted to coil C1 while the other end of the armature is repelled by C2. As a result, the clapper strikes G2. On the other half of the alternating current (AC) cycle, when the current through the coils is reversed, the polarity of the electromagnet is reversed and the armature is attracted in the opposite direction. This causes the clapper to strike G1, as shown in the illustration. Obviously, alternating current passing through the ringer windings causes the armature to vibrate with the current alternations. In actual practice, the current used with ordinary ringers has a frequency of 20 hertz.

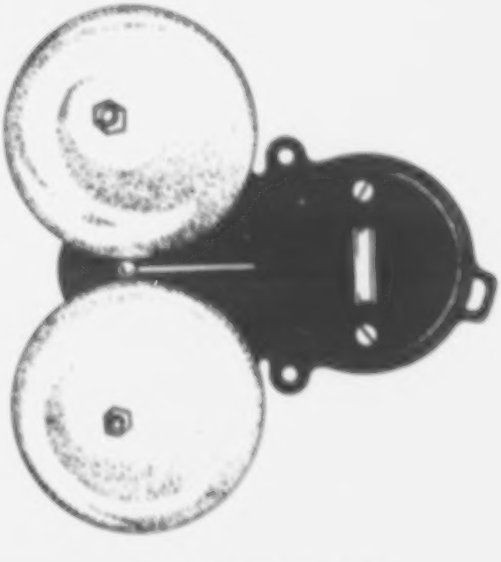


Figure 3-60. Loud ringing bell.

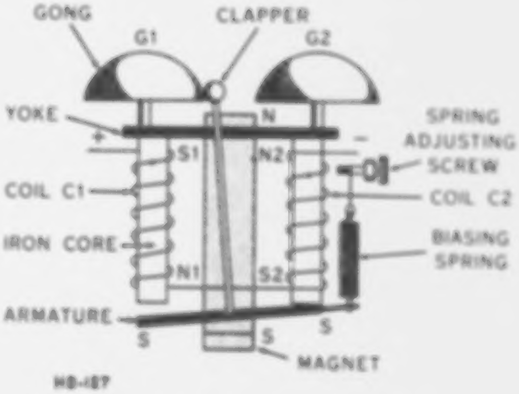


Figure 3-61. Illustrated ringer construction.

Note in figure 3-61 that the ringer has a biasing spring to regulate the movement of the armature. Although all biasing springs are not mounted in identical positions, they have the same purpose. When AC ringing current is used, the biasing spring prevents tapping of the bell when any current except ringing current flows through the set. By adjusting the tension of the biasing spring, you can stop such tapping and can also slightly change the sound of the bell. To repeat, the primary purpose of the biasing spring is to prevent bell tapping. While we are still thinking of ringers, it should be noted that some modern ringers use only one coil with two windings. The operating principles, however, are basically the same as those described in Volume 2 of this course.

If several people frequently use a subset, the addition of an extension subset may speed office or shop operations and increase the efficiency of the telephone. A typical installation might have two office telephones, one in an outer office and the other in an inner office.

Extension telephone installations are simple arrangements. Basically, we have two telephones connected in parallel so that they can operate from a single line. The two are joined to the line at the protector or through the use of a connection block, as discussed in this chapter.

Just as individual subsets may be installed with wiring through duct systems, so can you have a flexible arrangement for extension telephones; however, this arrangement is practical only for permanent wiring. You provide the flexibility with telephone outlets at selected locations; thus, you can attach the subset to any outlet. Frequently, use of a standard three-prong plug insures correct polarity for such an attachment; at other times, you make permanent connection at the outlets.

Transfer keys. Transfer keys are normally used in small installations where it is impractical to install complicated key systems and it is desirable to have more than one line connected to a single telephone set. Transfer keys are also usable where it is desirable to have one party answer all incoming calls and transfer the calls to other persons. There are numerous types of keys available, both pushbutton and lever types. Regardless of which type you install, locate them where they are the most satisfactory to the user from the standpoint of appearance and convenience. The usual practice is to mount the keys at the side of the desk or table leg. When connecting a transfer key, terminate it in accordance with the instructions for the type of apparatus used.

Special equipment. You may be called upon to install special equipment such as explosion-proof telephones, recording devices, and other specially designed apparatus.

Explosion-proof sets are intended for use at all locations where the atmosphere contains gases or vapors capable of exploding. These sets are constructed so that all parts of the apparatus which might cause a spark are completely inclosed. You must install rigid conduit with these explosion-proof telephones. Run the conduit from the set to a point outside the hazardous area and seal all openings in the conduit with an approved sealing compound. Generally you use all the normal installation practices except that you include a line switch to discharge the condensers whenever it is necessary to open the telephone set for servicing.

There are numerous recording devices manufactured that you can place at the subset to make recordings. Basically, there are two types: an induction type that merely requires an AC power source, and a directly connected type that must be wired across the telephone line. In any case, such devices are accompanied by complete instructions for installation. Recorders must be wired, however, to meet certain requirements. One of these is that there must be a ''beep'' signal applied to the line whenever the recorder is in use. Follow the instructions furnished with such special equipment and you should have little trouble with its installation.

Exercises (444):

1. Identify the telephone installed in conjunction with a condenser discharge switch.

2. Identify two auxiliary telephone signaling units.

3. What installed telephone unit allows calls to be heard more readily throughout a large shop area?

4. Name the simple, inexpensive device to install at a desk which permits an attendant to switch a call to a second user in the organization.

5. Identify a necessary component for the circuit of text figure 3-61 that is not now identified.

6. Using text figure 3-58, to what devices of the illustrated telephones are the line conductors attached?

7. Tell one method of strengthening a desk panel before installing a connecting block on it.

8. State two requirements for a desk telephone wire run.

9. How do you insulate telephone wires from contact with the metal of a desk?

10. Tell the connection principle for the two coils of text figure 3-61.

11. What connection method permits use of one telephone at several locations within one organization?

12. What type protection must be provided to the telephone wire run for an explosion-proof telephone?

CHAPTER 4

Station Termination and Testing

IN CHAPTER 3 we were concerned with the attachments used in the telephone substation area and with the installation of inside and outside building wiring, telephones, and auxiliary telephone devices. Once you have completed the installation of the building runs and station apparatus, you can then complete the connection to the telephone line or cable terminals.

To complete the connection from the building to the terminal-can, you must first raise the drop wire into place and attach it to the pole, providing the proper amount of sag. Secondly, you must connect the drop wire to the assigned terminal connections. And finally, after all of the connections have been made, you must test the completed installation for proper operation. This chapter tells you how to make the final connection and describes the necessary tests which insure satisfactory operation.

4-1. Cable Terminations

Before you consider drop wire termination, you should recall that the drop wire extends from the building to the terminal pole and that it is connected to terminals inside the terminal-can. These terminals are connected to cable pairs which extend through the cable to equipment at the central office. So in reality, when you connect the drop wire to terminals in the terminal-can, you are connecting the subset installation to equipment at the central office.

445. Cite drop wire load and sag requirements, and specify typical preparational procedures for wire termination.

Preparation. The procedure for wire termination is relatively simple—it requires bringing the wire from the building to the terminal pole, placing it with the proper sag, and completing good electrical connections. The general practice in placing span runs is to work from the first building attachment out to the terminal pole. The span may run directly to the terminal pole or, to miss trees and other objects, the span may first run to an intermediate pole or to a span clamp mounted on an aerial cable suspension strand. A typical procedure for placing a span directly to a terminal pole is given in the following subparagraphs and is essentially the same in all cases.

a Place the drop wire reel assembly on the ground close to the building, as shown in figure 4-1. Arrange the reel so that the wire pays out from the bottom.

b Make sure that the building run is already completed.

c. Carry the drop wire reel assembly out to the terminal pole. Pay out the wire on the ground, allowing sufficient slack for the wire to lay flat on the ground. Place the drop wire reel assembly next to the terminal pole. If the drop wire crosses a roadway, remember to take any precaution necessary to protect it from being run over by passing vehicles. If the wire is damaged, however, inspect it and replace any damaged portions.

d. Climb the pole and install a drive hook to support the drop wire. On aerial cable poles, when you can throw a handline over the suspension strand, you may install the drive hook later. At locations where traffic is heavy, install the drive hook before the other placing activities are begun.

e. Place the handline over the drive hook. Adjust the handline until both ends rest on the ground.

f. Descend from the pole. Tie the end of the handline that is nearest the building to the drop wire, using a bowline knot.

g. Adjust the brake of the drop wire reel assembly to provide a drag on the drop wire and to prevent the reel from spinning freely.

h. Take up the free end of the handline and slowly raise the drop wire to the drive hook or suspension strand (fig. 4-2).

i. Secure the drop wire in this position by tying the free end of the handline to a pole step or to the base of the pole with a clove hitch (fig. 4-3).

j. Climb the pole. If the drive hook was not previously installed (step 4), install it.

k. Pull up the drop wire to the desired sag. Attach a drop wire clamp to the drop wire. Place the loop of the drop wire clamp over the drive hook.

l. Remove the handline from the drop wire. Cut the drop wire at a point that will provide enough wire to run from the drive hook to the cable or drop wire terminal.

m. Install the necessary intermediate pole attachments and run the drop wire to the cable terminal or to the drop wire terminal. Terminate the drop wire.

Sag Requirements. Now let us consider some principles for the preceding steps. For example, clearance requirements, appearance considerations, and the possibility of damage from swinging contacts with other wires or obstructions will determine the maximum sag that may be placed in a drop wire span. Normal practice is to sag the drop wire at approximately (but not less than) the minimum sag given in table 4-1. These stringing sags will provide a favorable operating tension in drop wire spans and still maintain required ground clearance under usual construction conditions. At these minimum sags, the stringing tension will be approximately 30 pounds. The table has been compiled to cope with the normal weather conditions experienced in various parts of the country. Figure 4-4 illustrates the storm loading district map you should consult to determine which portion of table 4-1 to use in calculating the proper stringing sag for a drop wire span. In areas where high winds, freezing rains, and wet snows are common, the upper part of the table sets the sag. Where milder weather is

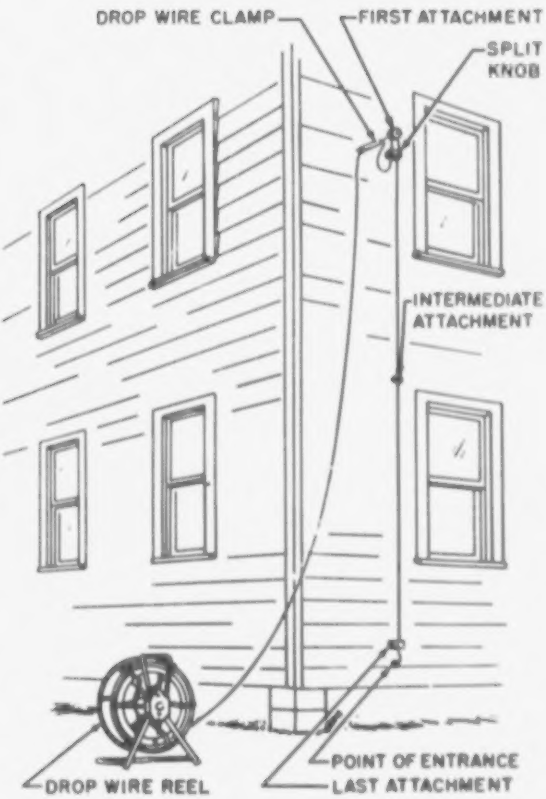

DROP WIRE CLAMP
FIRST ATTACHMENT
SPLIT KNOB
INTERMEDIATE ATTACHMENT
POINT OF ENTRANCE
LAST ATTACHMENT
DROP WIRE REEL

Figure 4–1. Reel arrangements for paying out drop wire.

experienced, use the lower portion of the table. Note how a heavy load of ice and snow will stretch a span, thus increasing the amount of sag.

Add the proper stringing sag to the drop by finding the amount on the table and measuring that amount from the first attachment on both the building and the pole. Sighting from the marked point on the pole to the marked point on the building will indicate the amount of sag. If any portion of the span extends below the line of sight, the sag exceeds the minimum requirement. When, because of clearance or separation requirements or obstructions in the span run, you can't place the minimum sag in the proposed span run, you must usually provide protection for the drop wire wherever wire damage may occur between the building attachment and the terminal.

Exercises (445):

1. Identify two drop wire procedures that need to be done properly to insure reliable continuous telephone service.

2. When preparing to pay out wire for the telephone drop, where do you first connect the wire?

3. Identify the device used to raise the telephone drop wire to the pole top.

4. In what manner do you attach the handline to the drop so that the wire won't slip and fall back to the ground?

5. Identify the knot to use for keeping the raised drop wire up and near to the position for terminating the wire.

6. Cite the precaution to use when cutting the drop wire at the pole top.

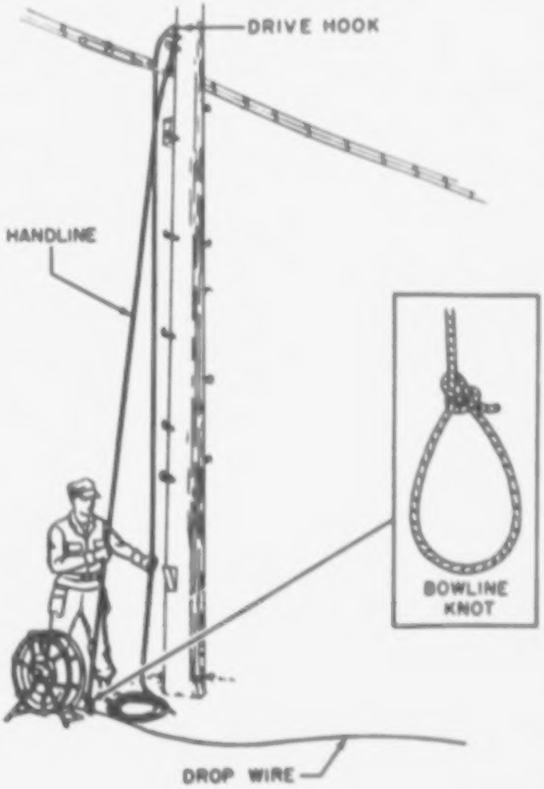

DRIVE HOOK
HANDLINE
BOWLINE KNOT
DROP WIRE

Figure 4–2. Raising drop wire.

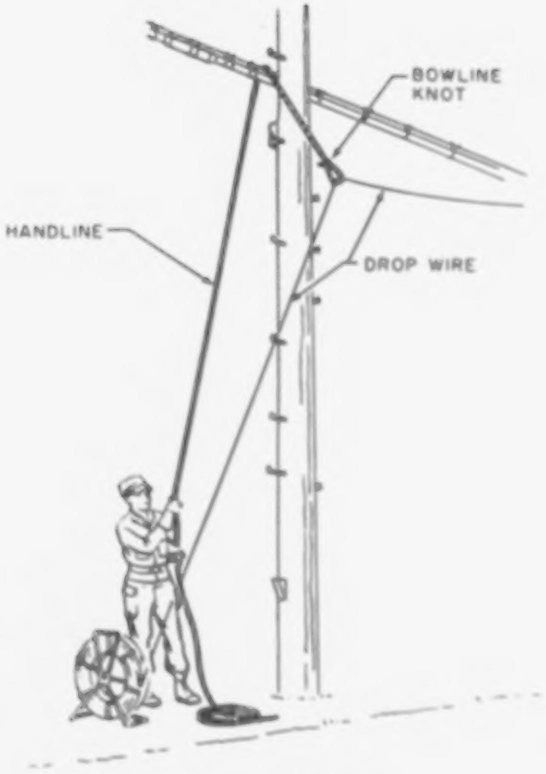


Figure 4-3. Securing handline.

7. Give two probable trouble factors to consider when sagging a drop wire.

8. According to table 4-1, what is the stringing sag for a light load zone area span 200 foot long?

9. What is the typical stringing tension for a drop wire span?

10. Using text figure 4-4 and table 4-1, specify the stringing sag for a 150 foot drop wire span in Iowa.

11. Using table 4-1, give the probable sag increase to be noted on a 250-foot drop wire span following an ice storm in Omaha, Nebraska.

TABLE 4–1

MINIMUM SAGS FOR DROP WIRE SPANS

SPAN LENGTH (FT)	STRINGING SAG	APPROX. FINAL UNLOADING SAG FOLLOWING STORM LOADING	SAG INCREASE FROM STRING TO FINAL CONDITION
HEAVY LOADING AREA			
50 (or less)	0 ft 6 in	0 ft 6 in	
75	1 ft 0 in	1 ft 0 in	
100	1 ft 9 in	2 ft 0 in	0 ft 3 in
125	2 ft 10 in	3 ft 4 in	0 ft 6 in
150	4 ft 0 in	4 ft 10 in	0 ft 10 in
175	5 ft 6 in	6 ft 7 in	1 ft 1 in
200	7 ft 0 in	8 ft 6 in	1 ft 6 in
225	9 ft 0 in	10 ft 10 in	1 ft 10 in
250	11 ft 2 in	13 ft 4 in	2 ft 2 in
MEDIUM AND LIGHT LOADING AREAS			
50 (or less)	0 ft 6 in	Same as Stringing Sags	No Increases
75	1 ft 0 in		
100	1 ft 9 in		
125	2 ft 10 in		
150	4 ft 0 in		
175	5 ft 6 in		
200	7 ft 0 in		
225	9 ft 0 in		
250	11 ft 2 in		

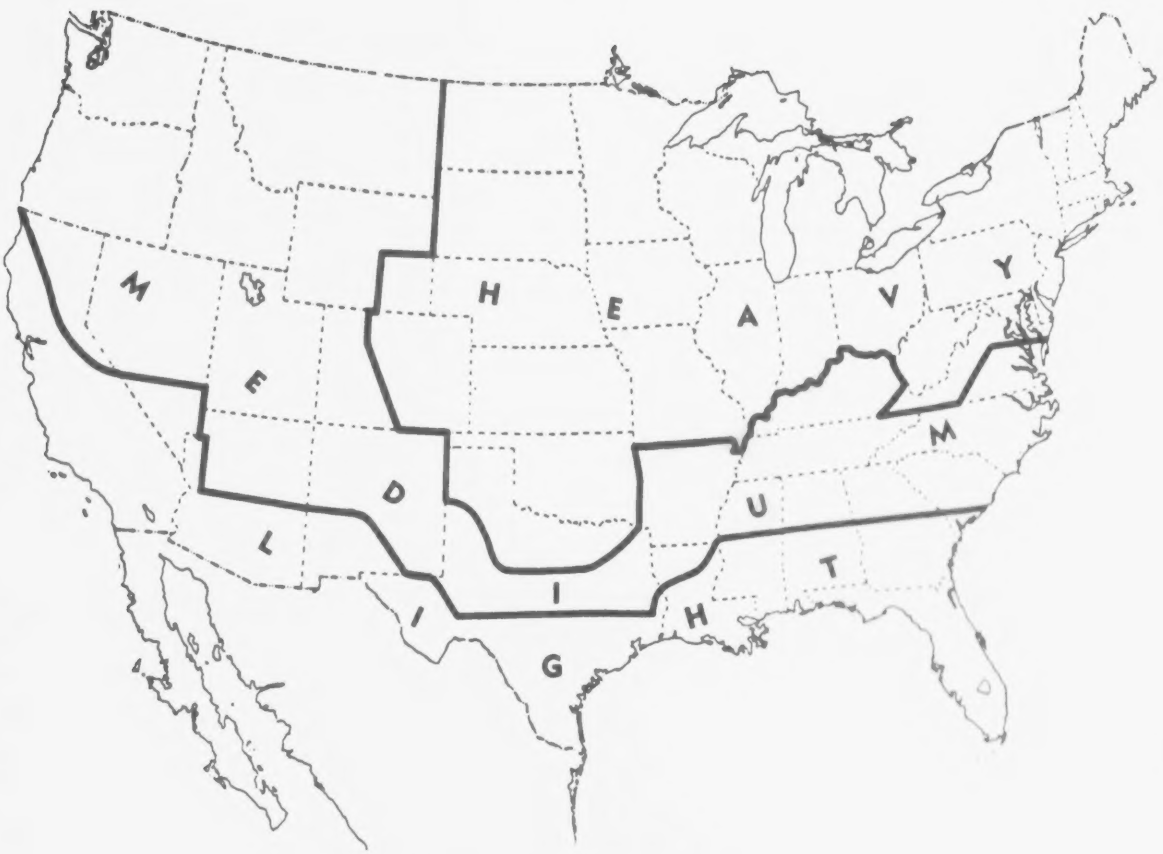


Figure 4-4. Nationwide loading zones.

446. Correlate descriptive and installation facts for cable terminal.

In general, the terminals used with aerial cable installations are as shown in figures 4-5 and 4-6. In figure 4-5, the terminal is shown mounted on the terminal pole, and in figure 4-6, it is shown attached to the cable.

Cable Terminal. With either type of installation, cable pairs are brought into the terminal unit and attached to the back of the terminals at the time of cable installation. Of course, cable installation personnel do this since they are responsible for terminating the cable. As a installer-specialist, you normally are not concerned with the connection of cable pairs to the terminals, but are concerned with the connection of drop wire leads to the terminals. As a matter of fact, you must connect the drop wire leads to specific terminals as specified by the installation work order. In order to install the subset, you must connect the leads to a cable pair which extends to available equipment at the central office.

Description. Some of the most recent outside plant cable installations include polyethylene sheath and conductor insulation. The use of this material permits use of a "ready-access" distribution terminal. Some of the features that are a part of this terminal are given in the following paragraph.

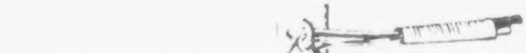


Figure 4-5. Example terminal installed on pole.

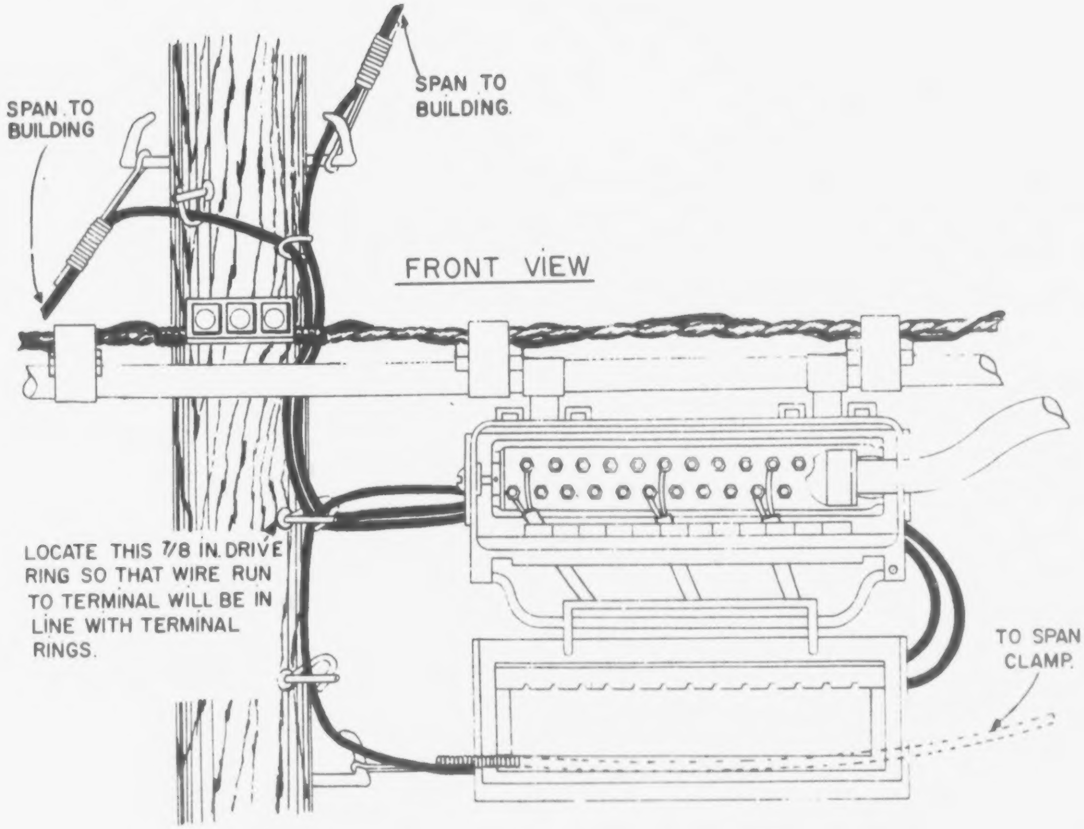


Figure 4-6. Front view of sheath-mounted terminal installation.

The ready-access cable terminal has three parts: a molded neoprene rubber cover which is weatherproof, a terminal base which consists of two metal strips with hangers which include 24 numbered entry points, and a terminal block which comes with attached cable that is to be connected by sleeving to the incoming cable. The terminal block uses a different color code than that used on older terminals. The tip binding posts are from left to right and are colored orange, white, brown, white, blue, and red. The ring binding posts are colored from left to right: white, blue, white, green, white and slate. Each ready-access terminal unit can support four of these terminal blocks which can terminate 24 pairs.

Terminal area. After the span run has been pulled up and sagged, you must terminate the drop wire at the terminal. This requires that you place intermediate attachments on the pole between the drive hook and the terminal and that you properly connect the drop wire. To enable you to become thoroughly familiar with the work in this area, look briefly at the terminals shown in figures 4-6 through 4-11.

The terminal area is very important when you are connecting drop wire. A primary requirement for a terminal installation is that you do new work properly and that you inspect any old plant installation in this area every time you are working at or near it, because the terminal area is a potential trouble area. As shown, the area generally includes the terminal and about 4 feet of cable on either side of the pole. Within this area the cables, wire, terminal-can, and any other part of the telephone plant are subject to damage. For instance, the cable sheath may be punctured by climber gaffs, or the terminal tail might develop trouble where it attaches to the can or where it bends.

Inspection and repair. You can sometimes spot trouble in a terminal area by making a visual inspection from the ground; therefore, make a practice of inspecting the terminal area if you are walking past any terminal pole. Always check the underside of the sleeve seal, which is a key place to look for holes or cracks in the wiped joint. Such inspection may reveal many poor installation practices. You can observe drop wire clearance, pole attachments, broken or leaning poles, improperly supported lines, loose lines, missing cable rings, and interference from trees. If you see a difficulty that you cannot correct at the time, you should report it to your supervisor or the wire chief so that maintenance can be performed as soon as possible.

Installers who intelligently make repairs within the terminal area are assets to their organization. A defect which

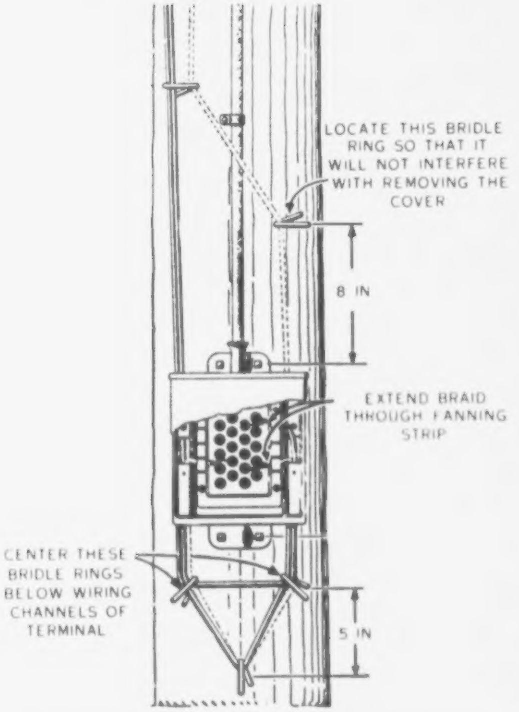

LOCATE THIS BRIDLE RING SO THAT IT WILL NOT INTERFERE WITH REMOVING THE COVER
8 IN
EXTEND BRAID THROUGH FANNING STRIP
CENTER THESE BRIDLE RINGS BELOW WIRING CHANNELS OF TERMINAL
5 IN

Figure 4–7. Typical requirements-pole mounted terminal.

can be cleared immediately, for example, an open circuit caused by a loose connection at the terminal, may require only a cleaning at the terminal and a tightening of the lugs with your fingers or a pair of pliers. If you find small holes in sheathing or seal and complete repair is impossible, you may prevent interruption of communications by an improvised repair, such as wrapping the cable with tape. Your report to the wire chief will indicate what has been done and will allow scheduling of permanent repair procedures.

Exercise (446):

1. Associate the terminal or component of column B with the facts of column A by placing the respective letter in the blank beside the applicable number. Two components are to be used more than once.

Column A	*Column B*
___ (1) White-green, white-slate identity.	a. Pole or sheath--mounted terminal.
___ (2) Gaff puncture probability.	b. Ready-access distribution termial.
___ (3) Has three parts.	c. Tip binding posts.
___ (4) Drop wire attachment.	d. Ring binding posts.
___ (5) Pair attachment is at back.	e. Terminal area.
___ (6) Can have 4 terminal blocks.	f. Cable sheath.
___ (7) Orange-white, brown-white identity.	g. Wiped joint.
___ (8) Has polythylene construction.	h. Cable ring.
___ (9) Has neoprene rubber cover.	i. Terminal tail.
___ (10) Four feet on each side of pole.	
___ (11) Trouble prbable at its bend.	
___ (12) Inspect for hole or crack.	

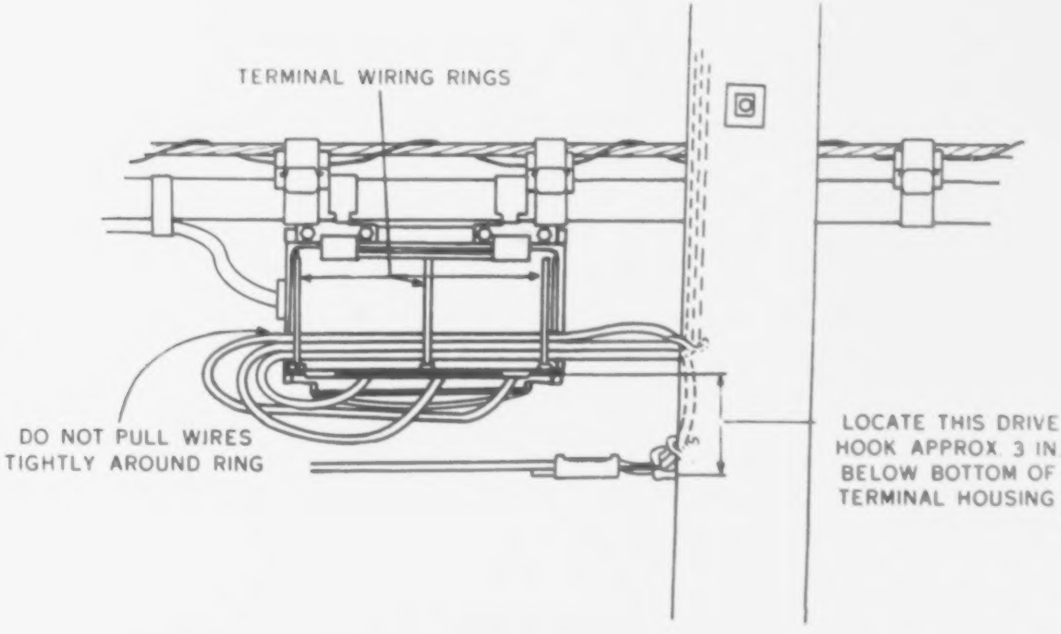

TERMINAL WIRING RINGS
DO NOT PULL WIRES TIGHTLY AROUND RING
LOCATE THIS DRIVE HOOK APPROX. 3 IN. BELOW BOTTOM OF TERMINAL HOUSING

Figure 4–8. Rear view of sheath-mount terminal.

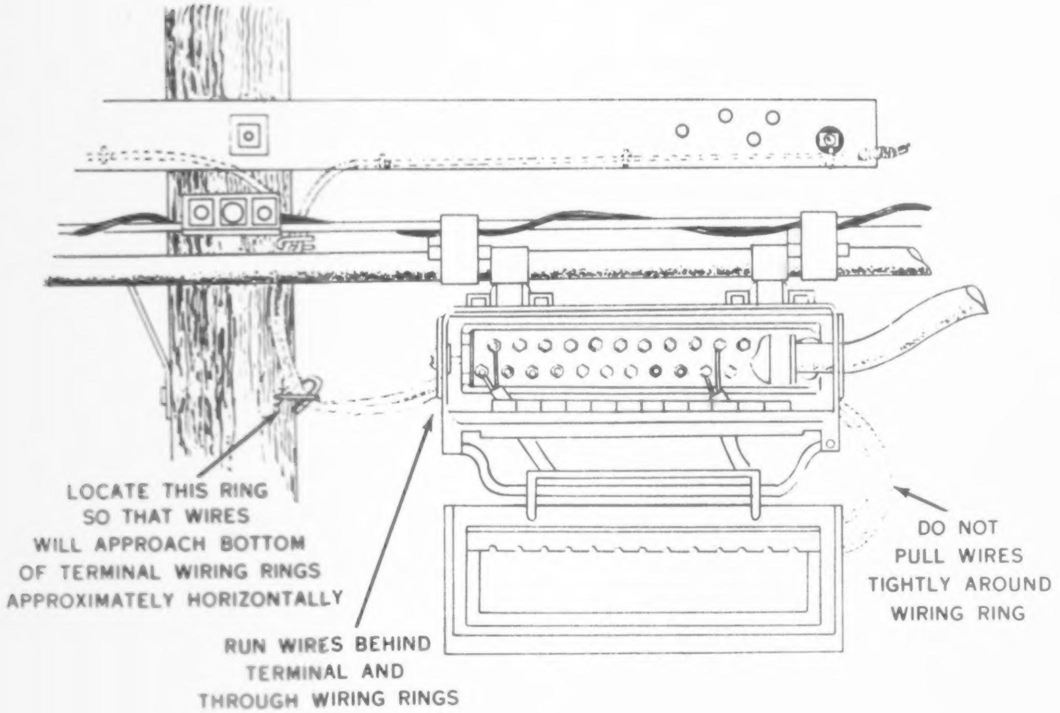

LOCATE THIS RING SO THAT WIRES WILL APPROACH BOTTOM OF TERMINAL WIRING RINGS APPROXIMATELY HORIZONTALLY
RUN WIRES BEHIND TERMINAL AND THROUGH WIRING RINGS
DO NOT PULL WIRES TIGHTLY AROUND WIRING RING

Figure 4-9. Wire runs to sheath-mounted terminal at pole guardarm.

447. Identify drop wire terminal units, and specify requirements and procedures.

The wiring at the pole end terminals of the drop wire run requires effective connections and a neat appearance. Figure 4-7 shows a closer view of pole-mounted terminal wiring, including the run on the pole and the arrangement of the bridle rings.

Terminating. Terminating includes the completion of a proper drop wire run on the pole. Note that you bring the drop wire to the designated terminal through the bridle rings. That is, run the wire first through the bridle rings highest on the pole and then through the rings above the proper wiring channel. To determine which wiring channel you should use, note the location of the lugs on which the wire will end. If you are facing the terminal and the binding posts for your drop are located near your left hand, bring the drop wire through the channel on your right. In other words, bring the wire through the side opposite the binding post to which it will be connected. Then thread the wire through all three of the bridle rings located below the terminal. By running the drop wire through the opposite channel, you leave extra wire so that if the wire is changed in the future, the installer can reach any pair of terminal bind posts by removing the wire from the lower bridle ring. The reconnected wire will then run from the channel to the two bridle rings and up the other channel to the terminal binding post.

Requirements. Remember to make the wire run on the pole according to the requirements of good appearance, and properly arrange each section of the wire run. Select the bridle ring locations so that you have sufficient wire clearance and neat vertical wire runs. In figure 4-7 note that the bridle ring spacing allows room for the terminal-can cover to be removed. Note also that the bridle rings are spaced according to the size of the terminal installed because, obviously, more space is needed for large terminals than for small ones.

Make wiring runs for sheath-mounted terminals also to give a uniformly neat appearance. Group each run in a wiring ring (see figs. 4-8 and 4-9). Locate this wiring ring so that the wires running to the terminal will be in line with the terminal rings.

Terminating drop wiring on sheath-mounted terminals is a simple operation. First, obtain the proper length of wire, and second, puncture the grommet in the wire entrance hole immediately below the proper binding posts. Figure 4-10 shows the termination, including the grommet.

Again, you must follow good electrical procedures for terminating. Skin and clean the ends of the conductor. Loosen the upper nut and washer of the terminal lug and terminate the tracer conductor (ring) on the right-hand binding post. Terminate the plain conductor (tip) on the left-hand post. This keeps the polarity of the system. The first conductor is usually placed under the lower washer and

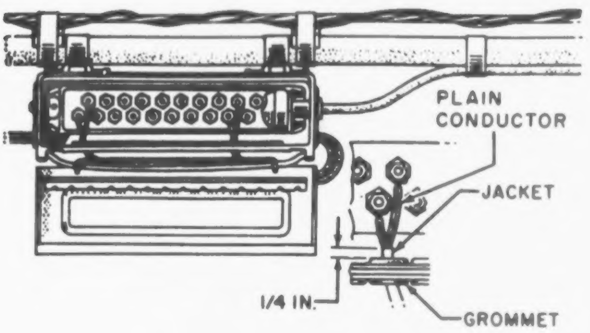

PLAIN CONDUCTOR
JACKET
1/4 IN.
GROMMET

Figure 4–10. Sample wire connections at sheath-mounted terminal.

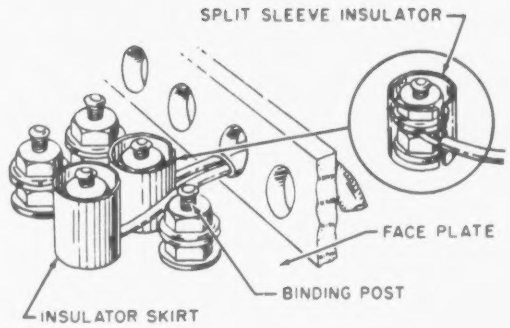

SPLIT SLEEVE INSULATOR
FACE PLATE
BINDING POST
INSULATOR SKIRT

Figure 4–12. Use of binding post insulators.

around the binding post in the direction in which the nut is tightened. Leave approximately a 1/8-inch separation between the insulation and washer (see fig. 4-11). Tighten the nuts to give a firm contact and to prevent the wire from accidentally contacting the adjacent binding posts.

Insulators. After you have terminated the wires in the terminal, install binding post insulators on lines of relatively great importance to prevent an accidental cross to another circuit. In commercial services these lines are picture transmission, teletypewriter, alarm, and remote control circuits. The insulators may be either the sleeve or the cap type (see figs. 4-12 and 4-13). Binding post insulators are available in two sizes: No. 1 for 3/8-inch nuts on the ordinary binding post and 7–T fuses, and No. 2 for 7/16-inch nuts or 7–A fuses. Installation is simply a matter of slipping the insulator over the terminal. If the insulator does not fit securely, place a small piece of tape inside it.

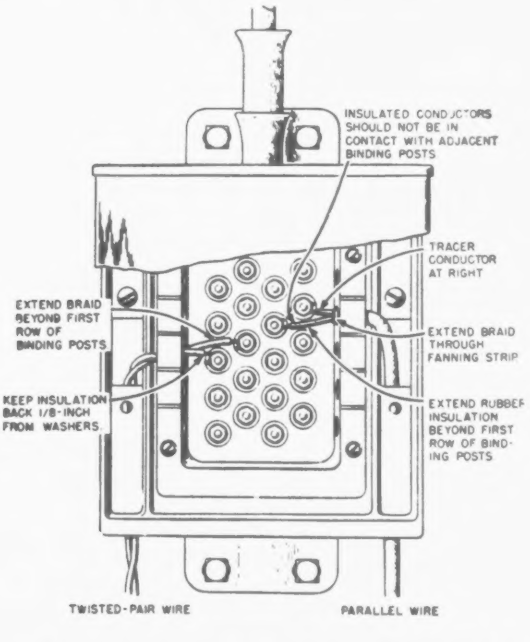

INSULATED CONDUCTORS SHOULD NOT BE IN CONTACT WITH ADJACENT BINDING POSTS
TRACER CONDUCTOR AT RIGHT
EXTEND BRAID BEYOND FIRST ROW OF BINDING POSTS
EXTEND BRAID THROUGH FANNING STRIP
KEEP INSULATION BACK 1/8-INCH FROM WASHERS
EXTEND RUBBER INSULATION BEYOND FIRST ROW OF BINDING POSTS
TWISTED-PAIR WIRE
PARALLEL WIRE

Figure 4–11. Wire termination at pole-mounted terminal.

Bridging. Where party lines are involved or where several telephones are connected to the same cable pair, you must frequently connect three wires together. This connection, called bridging, is always necessary when three drop wires must be connected to the same cable pair. Since connecting more than two wires on any post within the terminal-can is not advisable, connect the third pair of wires outside the terminal box on the applicable drop wire. Figure 4-14 shows a partially completed bridge connection. Notice that the third drop wire is brought around the terminal box to the point of connection in the same manner as the regular drop wire runs.

Figure 4-15 shows the 1–A type bridging connector you should use, and figure 4-16 shows how the wire is prepared for the bridge. This detail is comparable to the work shown in figure 4-14. Remember, you may insulate bridging connections by wrapping them with rubber tape, over which you place friction tape for additional protection. Do not locate the bridge within any bridle ring.

Bridging is frequently necessary at sheath-mounted terminals and you do it similarly to that performed for pole-mounted terminals. Figure 4-17 shows two wires bridged to one pair of binding posts. Note that the outer covering of the drop wire extends at least 1/4 inch inside the terminal. If three or four wires are to be bridged together, you must use a wire terminal, as shown in figure 4-18. Here we

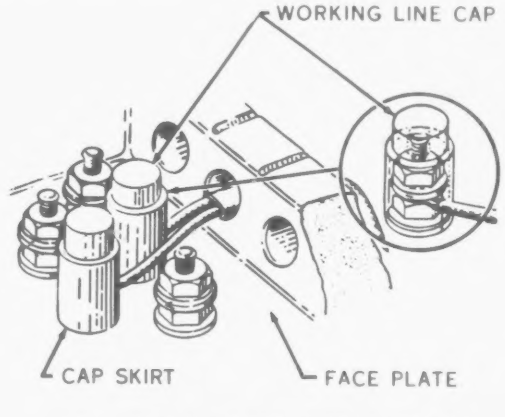

WORKING LINE CAP
CAP SKIRT
FACE PLATE

Figure 4–13. Use of cap binding post insulators.

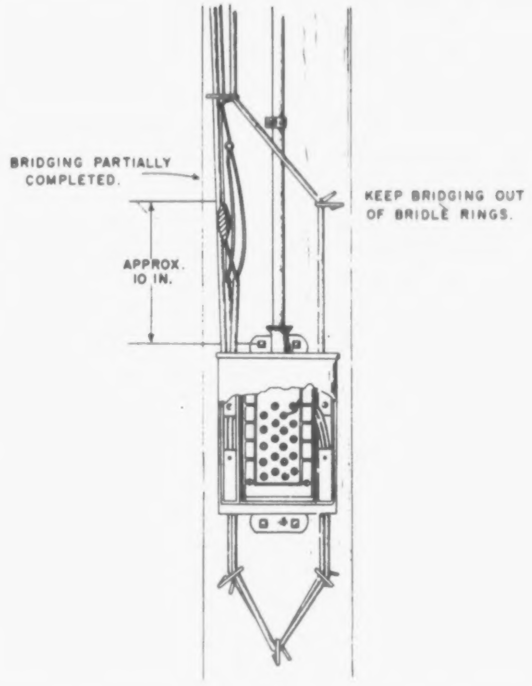

BRIDGING PARTIALLY COMPLETED.
APPROX. 10 IN.
KEEP BRIDGING OUT OF BRIDLE RINGS.

Figure 4–14. Bridging of three wires at a pole-mounted terminal.

see the pair of bridle wires from the sheath-mounted terminal entering through the rubber grommet on the left and fastened to the two binding posts. Two parallel drop wires enter through the right grommet. One conductor from each pair is connected to the binding posts. The tight-fitting rubber grommets help protect the inside of the terminal from moisture.

Exercises (447):

1. Through what devices do you run a drop wire before inserting it in a pole-mounted terminal?

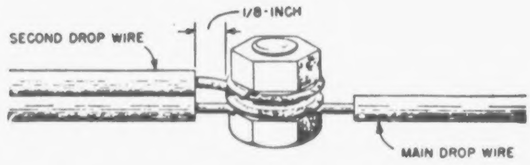

1/8-INCH
SECOND DROP WIRE
MAIN DROP WIRE

Figure 4–15. 1–A type bridging connector installed.

2. What is the approximate vertical separation between pole-mounted bridle rings?

3. Tell the proper method for determining slack for a drop wire being terminated at a pole-mounted terminal.

4. Tell two requirements for a telephone installation.

5. What method of attachment is to be used on a pole-mounted terminal?

6. Identify two typical binding post insulators.

7. State the name for a drop wire termination where three or four wires are connected together.

4-2. Open Wire Termination

Open wire is rarely, if ever, used for new installations. However, so much of this type of wire is already in service there is a good chance that sooner or later you'll be called upon to terminate a drop or clear up a trouble condition at an open line termination. For these reasons, you should understand the principles of open wire termination.

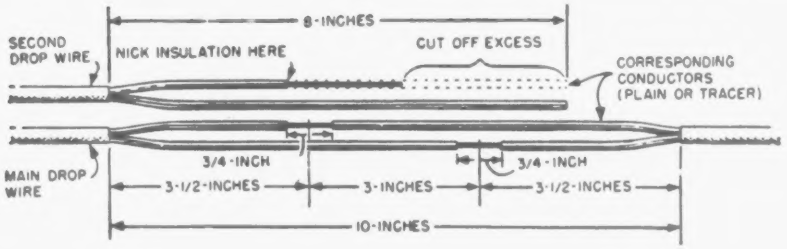

8-INCHES
SECOND DROP WIRE
NICK INSULATION HERE
CUT OFF EXCESS
CORRESPONDING CONDUCTORS (PLAIN OR TRACER)
3/4-INCH
3/4-INCH
MAIN DROP WIRE
3-1/2-INCHES
3-INCHES
3-1/2-INCHES
10-INCHES

Figure 4–16. Parallel drop wire preparation illustrated.

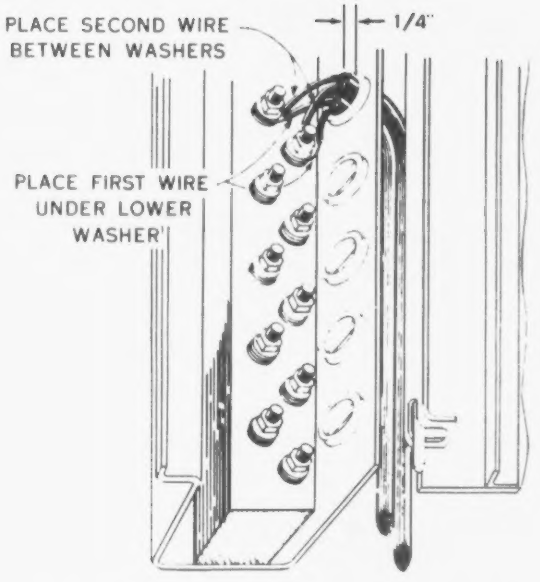

PLACE SECOND WIRE BETWEEN WASHERS
1/4"
PLACE FIRST WIRE UNDER LOWER WASHER

Figure 4-17. Two-wire bridging at sheath-mounted terminal.

448. Identify three parts of an open wire terminal, and give typical terminal requirements.

Drop Wire Terminal. The drop wire terminal (fig 4-18) consists of a faceplate, mounting base, and cover which hinges on the mounting base. Mounted on the faceplate are two binding posts, each equipped with a pair of washers and hexagonal nuts. The mounting base contains two mounting holes and two wire-entrance holes. The wire-entrance holes are equipped with rubber grommets, as shown in figure 4-18. One wire-entrance hole is used as the entrance for the drop wire, and the other as the entrance for the bridle wire. A maximum of two drop wires and one bridle wire may be terminated on the binding posts of a drop wire terminal.

Terminal requirements. When terminations are to be made to open wire lines, terminate the drop wires at drop wire terminals. Use bridle wire for the connection between the drop wire terminals and the open wires. Locate drop wire terminals where they will be accessible and will not obstruct climbing space, although specific locations will vary with conditions at each installation. Whenever practicable, observe the following general rules:

a. On poles with standard crossarms, locate drop wire terminals on the side of the crossarm, with the lower edge of the terminal 3/4 inch above the bottom of the crossarm, as shown in figure 4-19. Locate the first drop wire terminal between the first and second wire from the pole. When required, space additional terminals 2½ inches apart on dead-end crossarms and 3½ inches apart on other crossarms.

b. At dead-end crossarms, locate drop wire terminals on the side of the crossarm away from the dead-end brackets.

c. On poles having pole brackets, locate the drop wire terminal between the pole brackets when the brackets are on opposite sides of the pole (fig. 4-20), and below the lower line wire when the brackets are on the same side of the pole (fig. 4-21).

Exercises (448):

1. Identify the open wire terminal device to which you attach the drop wire, and tell the method to use in making the attachment.

2. Where are you to attach the drop wire terminal on a standard crossarm?

3. Tell two basic installation requirements for drop wire terminals.

4. Using figure 4-19, identify the pole attachments to use for holding the drop wire against the crossarm and give the maximum separation distance for them.

5. Using figures 4-19 through 4-21, identify the device to use when connecting the drop wire to the open wire at the pole.

6. Give the location for a drop wire terminal when the open wires are supported by two brackets on the north side of a pole.

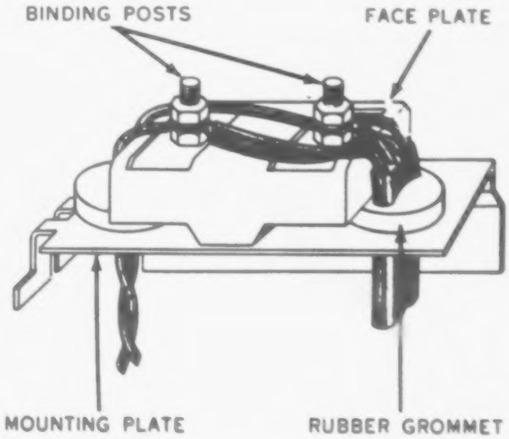


Figure 4-18. Example termination at a wire terminal.

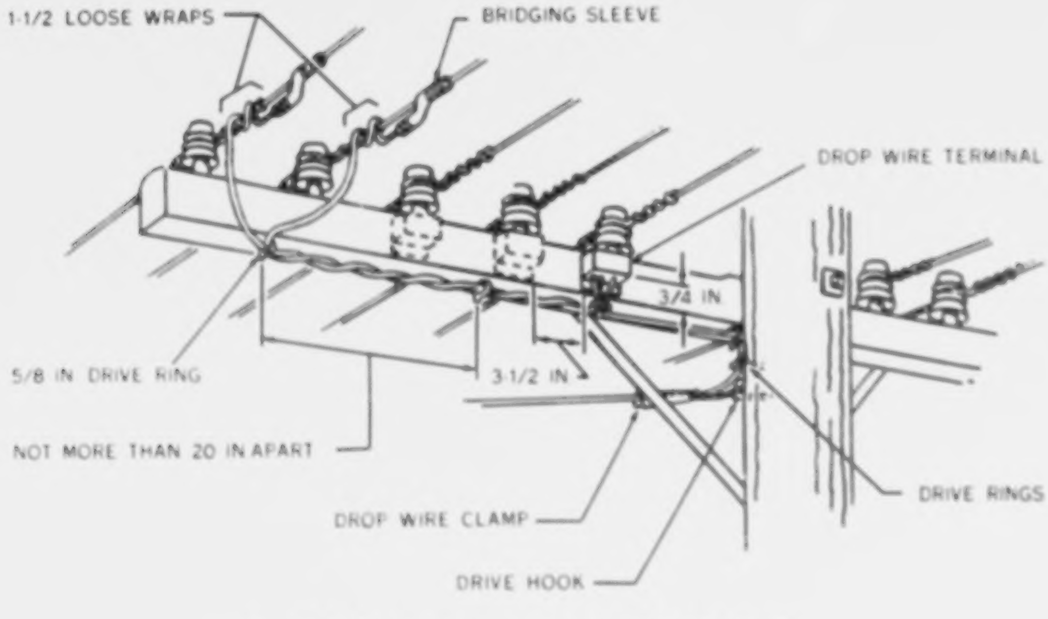

1-1/2 LOOSE WRAPS
BRIDGING SLEEVE
DROP WIRE TERMINAL
3/4 IN
5/8 IN DRIVE RING
3-1/2 IN
NOT MORE THAN 20 IN APART
DRIVE RINGS
DROP WIRE CLAMP
DRIVE HOOK

Figure 4-19. Drop wire termination at open wire pole with crossarm.

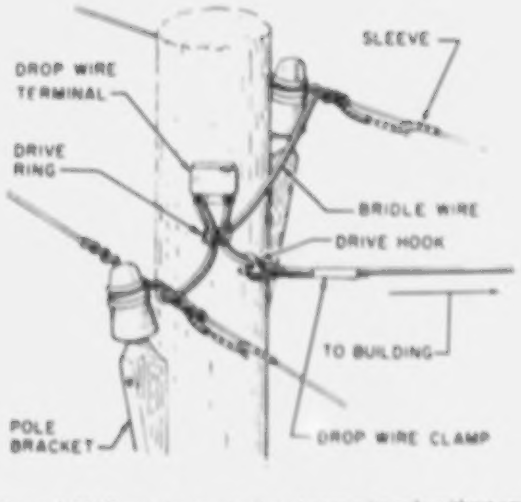

SLEEVE
DROP WIRE TERMINAL
DRIVE RING
BRIDLE WIRE
DRIVE HOOK
TO BUILDING
POLE BRACKET
DROP WIRE CLAMP

Figure 4-20. Drop wire termination at open wire pole without arms.

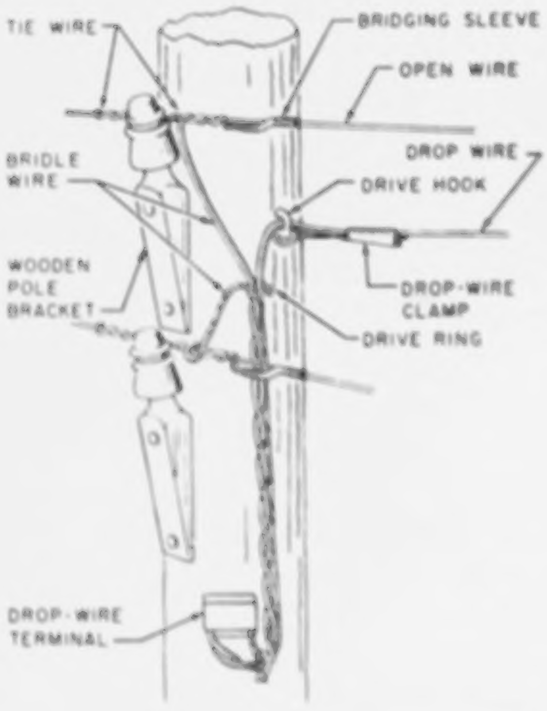

TIE WIRE
BRIDGING SLEEVE
OPEN WIRE
DROP WIRE
BRIDLE WIRE
DRIVE HOOK
WOODEN POLE BRACKET
DROP-WIRE CLAMP
DRIVE RING
DROP-WIRE TERMINAL

Figure 4-21. Drop wire termination at pole having wires on one side only.

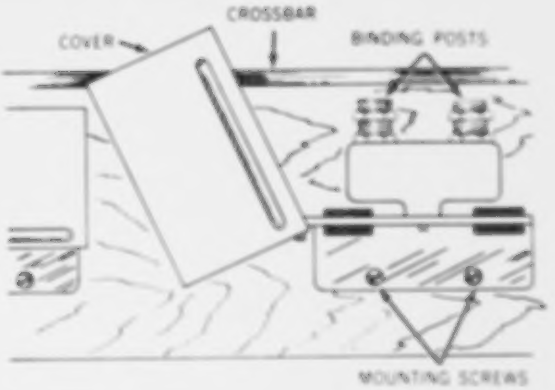


Figure 4-22. Typical mounted drop wire terminal.

449. For given situations involving terminal installation, state the proper procedures to use.

Terminating procedures. Install a drop wire terminal with the binding posts pointing upward, as shown in figure 4-22. Attach the terminal to the crossarm or pole surface with two 1-inch No. 14 roundhead wood screws; then run the wiring as shown in figure 4-19.

Arrange the attachments and the drop and bridle wiring as follows:

a. When the drop wire is run to a drive hook on the pole, install one 5/8-inch drive ring close to the drive hook, and another 5/8-inch drive ring on the underside of the crossarm close to the pole. Install additional intermediate drive rings as required to limit the spacing between rings to approximately 20 inches.

b. When the drop wire is run to a drop wire hook on the crossarm, install the first 5/8-inch drive ring on the underside of the crossarm below the drop wire hook. Note in figure 4-23 that the drive ring is not located immediately below the drop wire hook, but allows the drop wire to be run in a smooth curve from the hook.

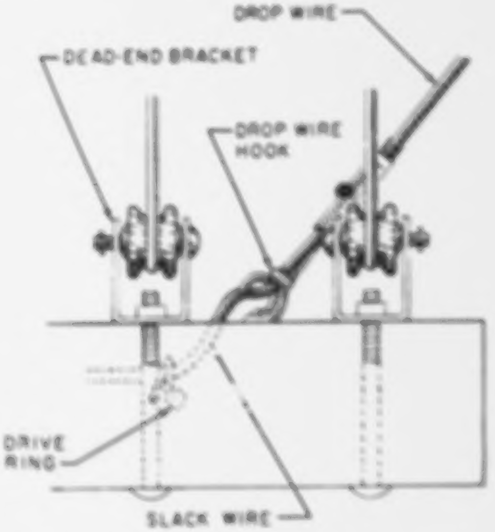


Figure 4-23. Drop wire hook installed on crossarm.

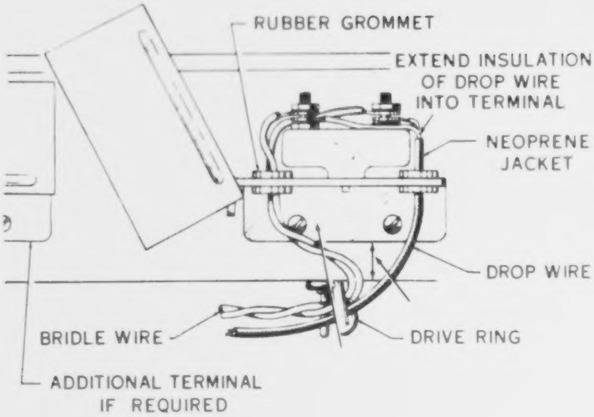

RUBBER GROMMET
EXTEND INSULATION OF DROP WIRE INTO TERMINAL
NEOPRENE JACKET
DROP WIRE
BRIDLE WIRE
DRIVE RING
ADDITIONAL TERMINAL IF REQUIRED

Figure 4–24. Wire connection at drop wire terminal.

c. Install a 5/8-inch drive ring on the underside of the crossarm directly below the drop wire terminal.

d. Install another 5/8-inch drive ring on the underside of the crossarm midway between the line wires on which the drop wire is to be terminated.

e. Install additional intermediate drive rings on the underside of the crossarm as required to limit the spacing between rings to approximately 20 inches.

f. Run the drop wire from the drive hook or drop wire hook through the drive rings to the drop wire terminal.

g. Strip a sufficient length of neoprene jacket and rubber insulation from the end of the drop wire to permit terminating the conductors on the binding posts of the drop wire terminal. Leave enough of the neoprene jacket on the drop wire so that the jacket extends inside the terminal to a point where sunlight cannot reach the rubber insulation of the drop wire. Figure 4-24 illustrates a completed, crossarm-mounted, drop wire termination.

h. Pass the drop wire through one of the wire-entrance holes in the drop wire terminal. Terminate the conductors of the drop wire under the lower washers of each binding post. If the wire-entrance hole does not have rubber grommets and if replacement grommets are not available, wrap enough 3/4-inch friction tape around the drop wire to seal the entrance hole.

NOTE: If a second drop wire is to be bridged to the same pair of line wires, run the second wire through the same entrance hole and terminate its conductors between the two upper washers on each binding post. If three or four drop wires are to be bridged to the same pair of line wires, install another terminal for the additional wires.

i. Select or cut a length of bridle wire long enough to run from the drop wire terminal to the line wires on which the termination is to be made.

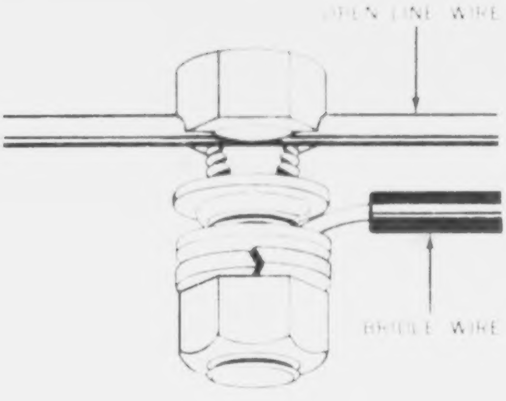


Figure 4-25. Example connection at bridging connector

j. Strip enough of the neoprene jacket and rubber insulation from one end of the bridle wire to permit the conductors to be terminated on the binding posts at the drop wire terminal. Pass this end of the bridle wire through the second wire-entrance hole in the drop terminal and terminate the conductors between the two upper washers on each binding post. If necessary, seal the entrance hole, as discussed in step *h*.

k. Run the free end of the bridle wire through the drive rings to the line wires.

l. Strip enough of the neoprene jacket and rubber insulation from the end of the bridle wire so that you can install a bridging sleeve on each conductor.

m. Take 1½ loose wraps of each conductor around the line wire to which it will be terminated.

n. Install each bridging sleeve on its corresponding line wire, as shown in figure 4-19. You may use a bridging connector similar to the one shown in figure 4-25 in place of a sleeve. Form a loop for the stripped end of the bridle wire and then slip it around the bolt between the two flat washers. Then position the bolt over the line wire, as illustrated, before tightening the nut to make a secure connection.

As indicated at the beginning of this chapter, when all terminations have been completed, check your installation to insure that the installation and the line to which it is connected are free from defects.

Exercises (449):

1. Using figure 4-23, identify a drop wire placement requirement at the crossarm.

2. If a crossarm is 42 inches long, approximately how many drive rings are needed between the pole and the open wire at the end of the crossarm?

3. State the task to do just before attaching the drop wires to the drop wire terminal binding posts.

4. What must you do to protect the incoming drop wire at the wire entrance hole?

5. Identify the type of wire to use to connect the drop wire terminal binding post with the open wire conductors.

6. State the difference in termination for the drop wire and bridle wire conductors at the drop wire terminal binding post.

7. Identify the two wires that are connected together by a bridging connector.

8. Tell the procedure by which the open wire and bridle wires are interconnected by the bridging connector.

4-3. Test Equipment and Operational Testing

Preventive and corrective maintenance of telephone equipment consists mostly of locating the troubles and then making the repairs. Although there are many test sets useful for locating the troubles, we are limiting our coverage to the Hand Test Set, multimeters, and click sets. There are a number of test sets available and several typical sets are shown in this section.

To insure that the subset installation is functioning properly, you must complete numerous tests at the time of installation. Even though central office personnel normally run a test on the assigned pair, you often are required to test the same pair from the terminal end before the termination is completed. Also, after having completed the termination, you must conduct another series of tests with the central office to find out if the newly completed installation is working properly. In case the equipment is not functioning properly, you should make the necessary adjustments or replacements to make certain that the new installation will give satisfactory service.

450. Using figure 4-26 as needed, correlate hand test set features and required tests you will perform when checking circuits.

The items of test equipment used by the telephone equipment specialist are measuring tools that provide essential information about electrical circuits. But no matter how good those tools are, the results will be only as good as the knowledge and ability of the person using them.

Hand Test Set. Figure 4-26 illustrates the TS–365GT handset, typical of the telephone test sets you will use as an installer-specialist. Note that this set is equipped with a dial that allows you to call into a dial exchange. Just clip the leads to the conductors or terminals of an operational line or cable pair and then dial the exchange after you receive a dial tone. When someone at the exchange answers, you can then proceed with your testing, or you can arrange for the test desk operator to check the circuit. In addition to this, you can use this set to determine if voltage is present on a circuit. Do so by listening for a click in the receiver when you connect the leads across the line or cable pair. You can identify the ring or battery side of the line by connecting one lead from the test set to ground and then by touching the other test set lead first to one side of the line and then the other. When the ring or battery side of the line is touched with the test set lead, you should hear a loud click in the receiver. Also, with an automatic system, you will hear a dial tone when you touch the test set lead to the ring or battery side of the line.

Exercise (450):

1. Match the hand test set features of column B with the tests listed in column A. Most units will be used more than once.

Column A *Elements Used*	*Column B* *Feature*
____ (1) Voltage test.	a. Alligator test leads.
____ (2) Dial tone test.	b. Dial.
____ (3) Tip (ground) line test.	c. Receiver.
____ (4) Talk test.	d. Transmitter.
____ (5) Ring (battery) line.	
____ (6) Dial equipment test.	

451. Correlate examples of multimeter controls and accessories with applications for each.

ME–70/PSM–6 Multimeter. Figure 4-27 is an illustration of the ME–70/PSM–6. As you recall, this test unit is used to measure resistance, AC and DC voltages, and DC current. It is designed to measure DC voltages up to 5,000 volts, alternating current voltage up to 1,000 volts, direct current values up to 10 amperes, and resistance values up to 10 megohms. All the circuitry required to make these measurements is brought to the two test lead jacks shown in the figure.

Multimeter controls. The three controls, shown on the face of the meter, switch resistors of different values in series with the meter and the test leads. You can see in the schematic illustration of figure 4-28 that these internal resistors are called multipliers. When a large resistance is switched in series with the circuit and the scale on the meter is calibrated for this resistance, the meter is then capable of measuring a large voltage. By the same token, when a smaller resistance value is switched into the circuit and the scale is calibrated for the smaller value, the meter is then capable of measuring only smaller voltages.

As you should remember from your studies in the Resident Course, the basic meter movement is also used to measure different amounts of current. To accomplish this, the resistors (called shunts) are switched in parallel with the basic meter movement. Of course the meter scale must also be calibrated to match the different shunts. Also, as you perhaps recall, the basic meter movement can be used as an ohmmeter by placing a battery and variable resistance in series with the circuit. This, however, requires that the meter scale be calibrated in ohms or some other unit of resistance.

Looking again at the PSM–6 (fig. 4-27) you can see three controls. They are as follows:

(1) Function switch. A 7-position switch which selects the proper circuit elements in the meter to measure either voltage, current, resistance, or output voltage level.

(2) Range switch. A 7-position switch used to select the specific range of voltage, current, resistance, or output level for the desired measurement.

(3) Zero control. A control used on resistance ranges to zero the pointer when changing resistance ranges or to compensate for changes in battery voltage.

In the last few paragraphs we have been thinking of the basic meter movement as it is used to measure direct current values. This is only natural because the meter movement being considered is actually a DC unit. The multimeter, however, can also measure AC values. A rectifier unit (consisting of diodes) is switched into the circuit during AC measurements. Thus the AC values (voltages and currents) are rectified and applied to the meter in DC form.

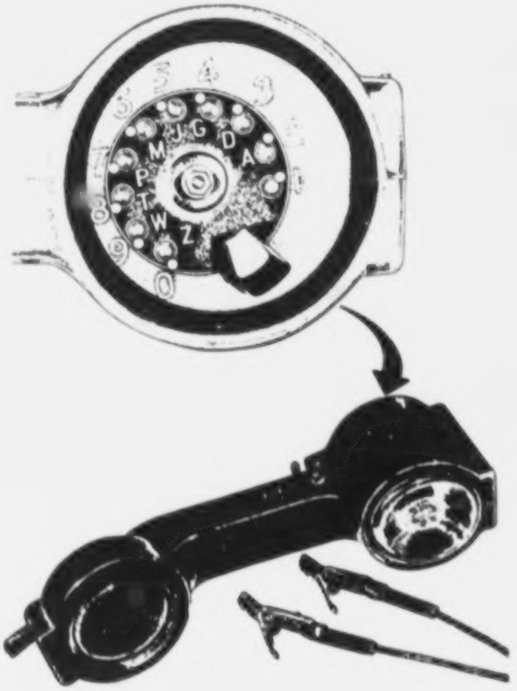
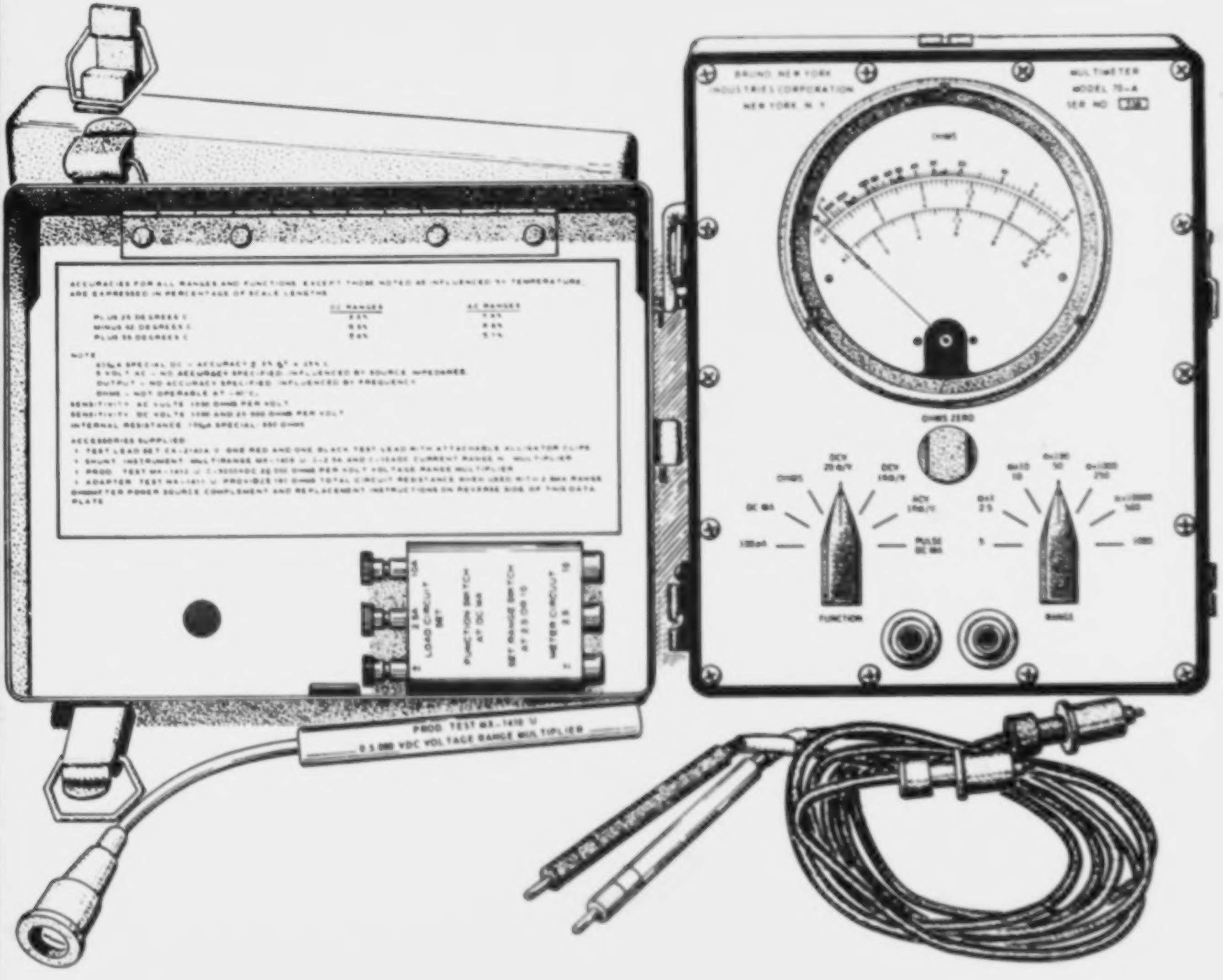


Figure 4-26. Hand test set (TS–365/GT).


BRUNO NEW YORK
INDUSTRIES CORPORATION
NEW YORK, N.Y.
MULTIMETER
MODEL 70-A
SER. NO.
OHMS ZERO
FUNCTION
RANGE
PROD. TEST MX-1410 U
0-5,000 VDC VOLTAGE RANGE MULTIPLIER

5A-030

Figure 4-27. Illustration—ME-70/PSM-6 Multimeter

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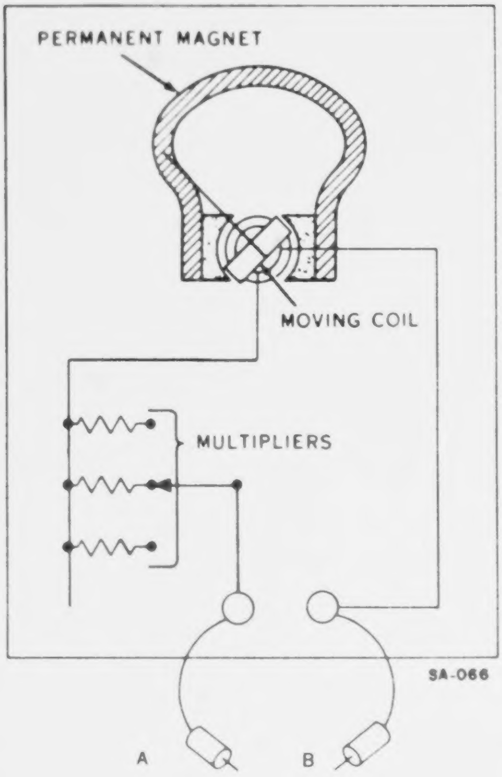

Figure 4-28. Basic voltmeter drawing.

Accessory units. We have said earlier that the multimeter PSM-6 has the capability to measure current up to 10 amperes. The purpose of the shunt MX-1409/U, shown in figure 4-27, is to increase the current measuring capability of the meter up to 10 amperes. Normally, when using the MX-1409/U, you set the range switch in the 10 position, then insert the meter leads into the 0 jacks on the MX-1409/U. Then connect the load under test to the binding post of the MX-1409/U.

The purpose of the accessory probe MX-1410/U is to extend the capabilities of the PSM-6, so that it can measure up to 5,000 volts DC. It works like this: With the meter set up to measure 500 volts DC on the 20KΩ/V function setting, plug the MX-1410/U in series with the positive test lead from the meter. Attach the clip of the MX-1410/U to the high-voltage test point to be measured. Then attach the negative test lead to the negative side of the voltage under test and apply power to the circuit under test. At this point, you can read the results (high-voltage reading) on the meter.

Exercise (451):

1. Place the letter for the PSM-6 unit of column B in the blank for the application statement of column A. Some units will be used more than once.

Column A
Application

____ (1) Selector for measurement factor.
____ (2) Compensates for battery voltage changes.
____ (3) Placed in parallel to basic meter movement.
____ (4) Selector for measurement level.
____ (5) Enables measurement of excess voltage.
____ (6) Enables resistance to be determined.
____ (7) Enables measurement of excess current.
____ (8) Placed in series for meter calibration.

Column B
Unit

a. Multiplier.
b. Shunt.
c. Battery.
d. Meter scale.
e. Function switch.
f. Range switch.
g. Zero potentiometer.
h. MK-1409/U.
i. MX-1410/U.

452. Specify PSM-6 control operations and settings for typical measurements.

Multimeter operation. The scales on the face of the meter are also shown in figure 4-27. There are three scales: OHMS, AC, and DC There is one set of numerals on the OHMS scale ranging from 0 to 3K. Of course, you can obtain numerous readings on this scale by using the different multipliers (R × 1, R × 10, etc) controlled by the range switch position. The AC and DC scales both have three sets of numerals ranging from 0 to 2.5, 0 to 5, and 0 to 10. How these scales are read when making a measurement depends upon the position of the control switches. As you study the various ranges of the meter, you should keep in mind that, depending on the position of the range switch, the AC or DC scales may be read as 0 to 2.5 or as 0 to 250. The 0 to 5 scale may be read as 0 to 5, 0 to 50, or 0 to 500. The 0 to 10 scale may be read as 0 to 10 or 0 to 1,000 on either scale; and as 0 to 100 on the DC scale for the special 100-microampere measurement. You should also remember that when the 0 to 5 scale is used as a 0 to .5 scale, you must imagine the decimal point to be in front of each number on the scale. As an example, the numbers 1, 2, 3, 4, and 5, are read as .1, .2, .3, .4, and .5.

With the function switch set in the DCV-20KΩ/V position, the multimeter circuitry provides 20,000 ohms per volt during the measurement. When this range is used, the meter has very little effect on the circuit being tested. High sensitivity makes it possible to secure accurate readings even when testing high resistance circuits carrying small amounts of current. With the function switch in the above position, use the range switch to select the desired measurement range. The following ranges for the measurement of DC voltages may be selected by the range Switch: 0 to .5 volts, 0 to 2.5 volts, 0 to 10 volts, 0 to 50 volts, 0 to 250 volts, 0 to 500 volts, and 0 to 1,000 volts.

If you position the function switch as described in the previous paragraph, and add Accessory Probe MX-1410/U, you can use the PSM-6 to measure voltages up to 5,000 volts DC. Briefly, this is done as follows: With the meter set up to measure 500 volts DC, plug the accessory probe in series with the positive test lead from the meter. Attach the clip of the accessory probe to the high voltage test point to be measured. After you attach the negative test lead to the negative side of the voltage source under test, apply power to the equipment and you can read the high voltage on the meter.

NOTE: When making high voltage tests, be sure that the power is off and that no residual high-voltage, capacitive charge remains at the voltage test point on the equipment under test when connecting or disconnecting the test leads.

With the function switch set in the DCV–1KΩ/V position, the multimeter circuitry provides 1,000 ohms per volt throughout all of the ranges selected by the range switch. Also, with the function switch in this position, you may use the range switch to select any of the voltage ranges except the 5,000-volt range. The 5,000-volt range, which requires the use of the accessory probe, is used only with the function switch in the DCV–20KΩ/V position.

When you move the function switch to the ACV–1KΩ/V position, a rectifier is connected to the meter circuit to rectify the AC voltage applied to the meter. The range switch may be used in any of its positions so that the meter can measure AC voltage up to 1,000 volts. The readings on the AC scale are made in the same way as on the DC scale.

When you set the function switch at the OUTPUT position, the circuit is identical to that of the ACV position—except that a series capacitor is added to the circuit. The function of this capacitor is to block any DC component of the AC voltage being measured.

When you place the function switch in the DC MA position, it actuates the circuitry that is used for all direct-current measurements. With each change in position of the range switch, the values of the resistors are changed so that all current in excess of 50 microamperes will flow through the meter shunt. To measure current in excess of 1 ampere, use the MX–1409/U Multirange Instrument Shunt. Adding this instrument shunt increases the current measuring capacity of the PSM–6 to 10 amperes. When you use the MX–1409/U, set the function switch at the DC–MA position, the range switch at the 10 position, and insert the meter test leads in the 10 jacks on the MX–1409/U. The load under test is then connected to the binding posts of the MX–1409/U. NOTE: Make all "connects" and "disconnects" with the power off.

When you place the function switch in the OHMS position, it prepares the basic ohmmeter circuit for measuring resistance. Here again the values of the resistors are changed with each setting of the range switch. As explained for the previous multimeter, you must adjust the ohms zero control on the PSM–6 (with the test leads shorted) to bring the pointer on the meter to zero. This must be done at the start of each resistance test and whenever the range switch is changed to a different position during resistance tests. Also, when you cannot adjust the meter to zero, it is quite likely that the batteries in the multimeter need to be replaced.

With the meter adjusted to zero, any unknown resistance connected in series with the test leads will naturally cause a reading on the meter that is less than full scale. You then read the value of the unknown resistance on the ohms scale of the meter. For greater accuracy, take resistance measurements with the range switch in the position that allows the pointer to fall upon the part of the scale where the scale graduations are farthest apart. (The two batteries used in the PSM–6 are plastic-coated 12.06- and 1.34-volt mercuric oxide batteries.)

The 100μA position of the function switch enables the PSM–6 to measure extremely small amounts of current. The range switch is not included in this circuit. When switched to this position, the circuit is simply a 1,700 ohm resistor shunting the 1,700-ohm meter resistance, thus forming a parallel resistive network of two equal branches. When placed in series with a 100-microampere (or less) current path, the current divides equally between the two branches, deflecting the meter pointer to full scale if the applied current is the full 100 microamperes. To interpret the meter reading with the function switch in this position, you must use the 0 to 10 DC scale. Of course, when doing this, you must add a zero to each of the indicated scale values. For example, since a full-scale reading is equal to 100 microamperes, the 10 on the scale must be read as 100, the 8 must be read as 80, the 6 must be read as 60, the 4 must be read as 40, and so on, over the entire scale.

Exercise (452):

1. Match the PSM-6 function control and setting and test measurment of column B to the control and setting of column A. Note, select the best setting for the test.

Column A	*Column B*
____ (1) Range - 2.5.	a. Function–DCV/20K - 20 volts.
____ (2) Range - 10.	b. Function–DCV/20K - 2000 volts.
____ (3) Range - Ω × 100.	c. Function–DCMA - 2 amperes.
____ (4) Range - 50.	d. Function–DCV/1K - 1 volt.
____ (5) Range - 10.	e. Function–Ohms - 64 ohms.
____ (6) Range - Ω × 1, Ω × 10, etc with test leads shorted.	f. Function–Ohms - 0 ohms.
____ (7) Range - 500.	g. Function–100 A - 4 amperes.

453. State typical testing applications for the AN/PSM–6 multimeter.

Multimeter applications. The applications of a multimeter in a communications system are many and varied. However, you will be mainly concerned with checking your equipment for opens, proper voltage, and shorts. Let's take a look at these conditions and see how effective the multimeter is in checking them.

In figure 4-29 you see a DC circuit with an applied voltage of 30 volts and three 30-ohm resistors in parallel. Now, let us suppose that this circuit is a part of a major circuit problem you are testing. Let us further assume that your technical order procedure indicates that there should be a total of 3 amperes of current in this circuit. At this point, you series-connect the multimeter with the applied voltage, but your reading indicates only 2 amps. Well, apparently something is wrong. Let's find out. To begin with, you'll have to agree that the total resistance of the circuit should be 10 ohms. The formula for equal resistors in parallel is:

$$RT = \frac{R}{N}$$

where N is the number of resistors.

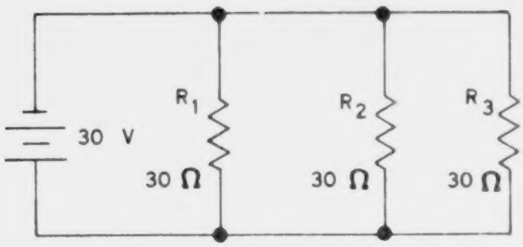

Figure 4–29. 30-volt DC parallel circuit.

Furthermore, you must remember the reason current will decrease in a DC circuit is that the total resistance increases. Now the DC arises: What will cause the total resistance to increase? Answer: An open resistor. You can readily see that if any one of the three branch resistors opens, the resistance will increase to 15 ohms. Now another question: Which resistor is open—which one causes the loss of 1 amp of current? This is where the multimeter comes into play.

By selecting the proper settings on the multimeter and connecting in series with each branch resistor, you'll find the open resistor. For instance, if you connect the meter in series with resistor R1 and obtain a reading of 1 amp, that resistor is good. The reason: 30V divided by 30 ohms equals 1 amp. The same rule applies to resistor R2 and R3. Suppose you check R2 and obtain a 1-amp reading, but R3 gives you a reading of zero. Here's the culprit! Any time you check a branch of a parallel circuit with an ammeter, a zero reading will indicate an open branch.

Now, you can use an ohmmeter as well as an ammeter to check this situation. Using the ohmmeter, disconnect the voltage and parallel the ohmmeter with the resistor under test—in this case, R3. However, you should isolate the resistor from the circuit, because if you go across a resistor with the meter without isolating it, the resistor under test is in parallel with resistors R1 and R2. The reading on the meter would be approximately 15 ohms, the total resistance of R1 and R2. Therefore, you must be sure to isolate it before you check it. In this way the resistor being tested is not shunted, and your meter reading will indicate infinite resistance.

As you know, a short in a DC parallel circuit will usually open the circuit by blowing a fuse or releasing a protective device. This is because the total current passes through the shorted resistor, since current takes the path of least resistance. Now, in the case of a short circuit of this type, you will not be able to use an ammeter or voltmeter to test the shorted condition because, as soon as a resistor shorts, the fuse will blow. As a result, no current will flow in the circuit. Hence, you must check the shorted resistor with the ohmmeter by isolating it. A shorted resistor will give you a reading of zero resistance on the ohmmeter.

In communications work, continuity checks are very important, because with them you can immediately determine whether a communications line pair is good or bad. An ohmmeter is an excellent device for making continuity checks, because it contains its own power supply which will send current through a line pair under test. If you desire to check the continuity between a telephone and an equipment bay, it's simply a matter of shorting one end of the line pair under test and taking the complete loop reading at the other end with the ohmmeter. If the pair is good, you'll receive a scale deflection.

Exercises (453):

1. What are two test readings that indicate an open circuit component?

2. Specify tests that are made with the PSM–6 multimeter while having the function switch at OHMS and the range switch at Ω × 1.

3. Name the usual test for checking the potential at the circuit source and at various tests points.

454. Correlate precautions to be observed with specified multimeter test settings.

Multimeter precautions. Since there are so many precautions that must be observed when a multimeter is used, we have purposely condensed most of the information in this section into a series of brief statements. We will first consider general precautions, and then those that must be observed during specific tests.

During tests, general precautions must be observed. Since all meters are current-actuated devices regardless of their scale calibration, here are hints concerning meters in general:

a. Before using any multimeter, carefully read all the instructions furnished with it.

b. When you use any instrument, the area around the jacks and terminals must be clean and dry. This prevents surface leakage, which can cause error in readings on the more sensitive ranges.

c. The rotary switches on the front panel generally cannot be rotated continuously. Do not try to force them beyond the first or last position.

d. Never drop a meter or subject it to excessive mechanical shock.

e. Never try to measure the internal resistance of a meter movement with an ohmmeter, as the movement may be damaged by the high current required for ohmmeter operation.

f. Precautions to observe when using *voltmeters.* Although the voltmeter is a high-resistance device and is not so apt to be damaged by an excessive current flow, there are several hints concerning its proper use that you should observe. They are as follows:

(1) Always connect a voltmeter in parallel across the portion of the circuit in which the voltage is being measured.

(2) Use a range large enough to insure less than full-scale deflection.

]

(3) Observe the proper polarity in connecting the voltmeter across a DC circuit. You can avoid improper meter connections by observing the polarity markings on the meter and by remembering that the black meter leads are negative leads and the red leads are positive leads.

(4) Remember that the accuracy of a reading indicated by a voltmeter depends upon the sensitivity of the meter. A voltmeter is a current measuring instrument designed to indicate voltage by measurement of current flow through a resistance of known value.

g. Precautions to observe when using *ammeters*. There are a number of precautions that apply particularly to the use of the ammeter. They are as follows:

(1) Always connect an ammeter in series with the element through which current flow is to be measured.

(2) Never connect an ammeter across a source of voltage, such as a battery or generator. Remember that the resistance of an ammeter, particularly on the higher ranges, is extremely low and that any voltage, even a volt or so, may cause a very high current to flow through the meter and damage it.

(3) Use a range large enough to keep the deflection less than full scale before measuring a current. Form some idea of its magnitude, then switch to a large enough range or start with the highest range and work down until you reach the appropriate one. Most accurate readings are obtained at approximately half-scale deflection. Many milliammeters have been ruined by trying to measure amperes. Therefore, be sure to read the lettering either on the dial or on the switch positions and select the proper range before connecting the instrument to the circuit.

(4) Observe proper polarity in connecting the meter to the circuit. Many pointers have been ruined by a reverse swing due to reversed polarity.

h. Precautions to observe when using ohmmeters. The two precautions that must be observed when you use the ohmmeter are:

(1) Avoid connecting the ohmmeter across circuits in which voltage exists. Therefore, to remove all power from the equipment, remove the power plug, and discharge any capacitors connected in the circuit under test.

(2) Make all resistance measurements with your hands holding the insulated portion of the test prods. The resistance of the human body, under certain conditions, is low (less than 50,000 ohms) and may cause erroneous readings.

Exercise (454):

1. Place the identifying letter for the meter of column B in the blank before the precaution of column A that best relates. Some precautions apply to more than one meter.

Column A
Precautions

____ (1) Select range switch to position that will insure measurement without damaging meter.
____ (2) Use moderate pressure when operating controls.
____ (3) Connect meter in series with the circuit element to be measured.
____ (4) Observe polarity.

Column B
Meters

a. Voltmeter.
b. Ammeter.
c. Ohmmeter.

Column A
Precautions

____ (5) Don't use the meter in a powered circuit.
____ (6) Handle the meter with care to prevent shock damage.
____ (7) Connect the meter in parallel to the device to be measured.
____ (8) For best accuracy in reading, set the range to where the pointer deflects to the scale where the graduations are farthest apart.

455. Using figures 4-30 through 4-32, relate the desired test to the appropriate receiver click set.

Receiver Click Set. The receiver click set may be the only test device available to you for making continuity tests. Remember that these tests indicate when a circuit is complete. When current flows through the receiver in a completed circuit, it creates a magnetic force which moves the receiver diaphragm. Hence you will hear a click.

Figure 4-30 is a schematic diagram of a receiver click set. In this illustration, a telephone receiver and battery are connected in series with two test leads. Arranged in this manner, the set is used for testing circuits that have no source of power. When the circuit has its own source of power, the battery is not used in the click set circuit. When the click set has no battery, it can be used only on powered circuits and, generally speaking, must be used in series with the circuit.

To construct a click set using telephone components, you may use the standard telephone handset or a receiver headset. You must also have a 4½-volt battery. When you use a telephone handset in this way, remove the transmitter cap and transmitter element, as shown in figure 4-31. Inside the handset transmitter cavity, depending on the type of handset, you will find either two terminals that are connected to the receiver element through the handle of the handset or receiver conductors of the handset cord that extend through the handle to terminals on the receiver. In either event the click set can be constructed as shown by A, B, and C in figure 4-31. Note that the construction of a click set in this way connects the receiver and battery in series, as shown by the schematic diagram in figure 4-30.

A click set is simple to use. Suppose you want to check the circuit through a lamp from points 1 and 2, shown in figure 4-32. Since the click set is complete with its own battery, you

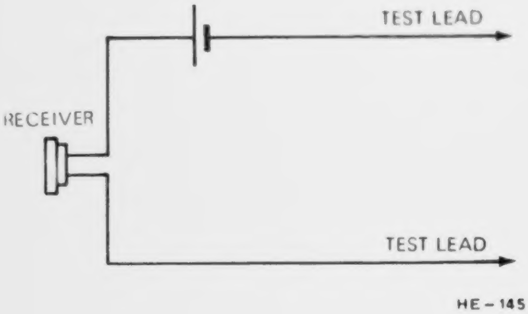

Figure 4-30. Receiver click set (schematic diagram).

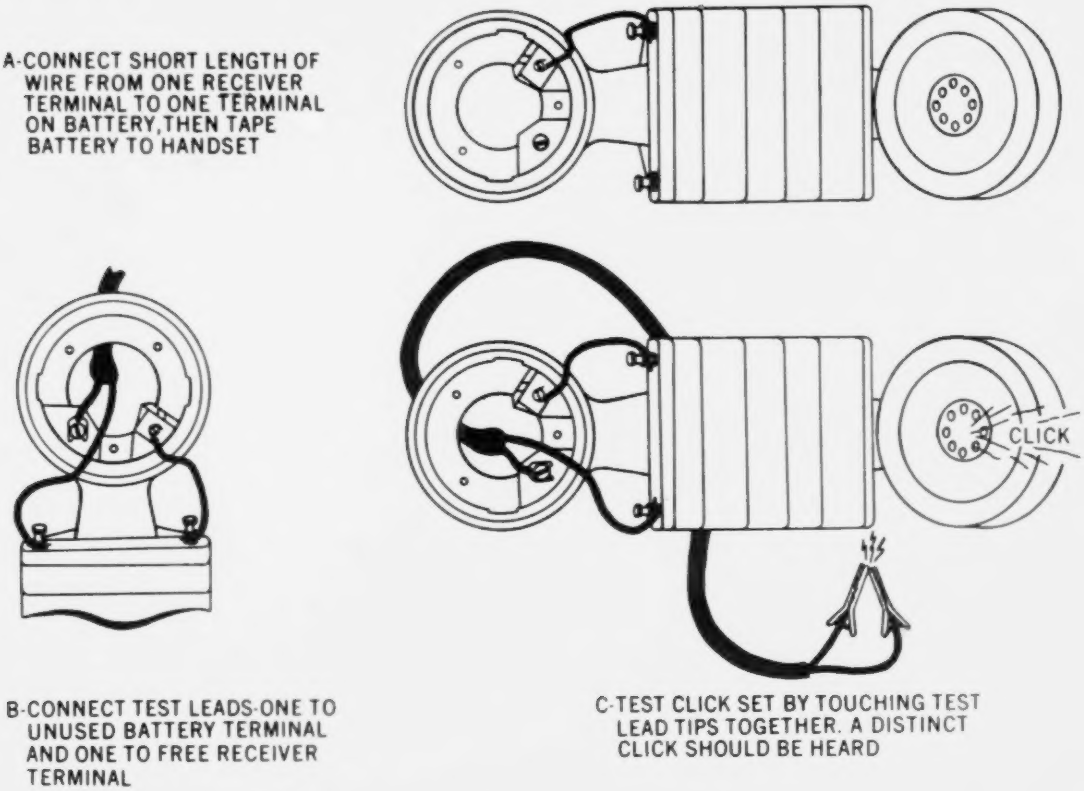
A-CONNECT SHORT LENGTH OF WIRE FROM ONE RECEIVER TERMINAL TO ONE TERMINAL ON BATTERY, THEN TAPE BATTERY TO HANDSET
CLICK
B-CONNECT TEST LEADS-ONE TO UNUSED BATTERY TERMINAL AND ONE TO FREE RECEIVER TERMINAL
C-TEST CLICK SET BY TOUCHING TEST LEAD TIPS TOGETHER. A DISTINCT CLICK SHOULD BE HEARD

Figure 4–31. Click set construction—illustrated.

need only to complete the circuit. At the time your test leads touch the two points as shown, you should hear a distinct click in the receiver. If you do not hear a click, the circuit between points 1 and 2 is incomplete. To prevent wrong interpretation, be sure you make all circuit tests carefully. Remember, sometimes corrosion at the contact points prevents current flow.

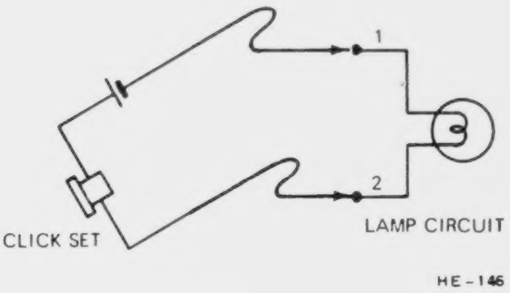
1
2
CLICK SET
LAMP CIRCUIT
HE-146

Figure 4–32. Sample use of click set.

Exercise (455):

1. In column A place the letter for the specific test set of column B. The letters may be used more than once.

Column A	*Column B*
____ (1) Test set component arrangement enables test of dead circuits.	a. Telephone receiver with battery.
____ (2) Receiver operates, thus showing that a circuit is complete.	b. Telephone receiver with leads only.
____ (3) Receiver leads and battery terminal arrangement is a series circuit.	
____ (4) Determines if the circuit has continuity.	
____ (5) Test set is usable with powered circuits.	

456. Specify operational test procedures, circuit elements tested, and example results for typical tests.

Operational Testing. You have learned that to insure proper function of the subset installation, you must complete numerous tests at the time of installation. Even though central office personnel normally run a test on the assigned pair, you are to test the same pair from the terminal end before the termination is completed. Also, after you complete the termination, you must conduct another series of tests with the central office to find out whether or not the newly completed installation is working properly. In case the equipment is not functioning properly, you should make the necessary adjustments or replacements to make certain that the new installation will give satisfactory service.

Before termination. Before the drop wire is terminated at the pole end, it is sometimes necessary to run a test of the assigned pair. You perform this test by connecting a telephone test set directly to the terminals of the assigned pair. If you can contact the central office in this manner and carry on a normal conversation, you can assume that you have good continuity between the terminals and the central office. If you cannot contact the central office over the assigned pair, call in over a spare pair (if available) to advise the wire chief of the situation.

Another test which you may perform with open wire lines is the one used to identify the conductors. As you know, the ring conductor is the battery side of the line and supplies the electrical energy for the talking circuit. The tip conductor provides the return path for the current to the central office ground, thus completing the talking circuit. Also, the ring conductor is negative with respect to either the tip conductor or to ground. Make the test to identify the conductors by connecting one lead of the test telephone to ground and the other test lead to first one conductor terminal and then the other. When you touch the ring terminal with the test lead, you should hear a loud click in the receiver of the test set. When you touch the tip terminal with the test lead, there should be either no click at all or a very slight click, depending on the difference in potential between the central office ground and the ground at the test location.

As an additional check to verify proper identification of the ring conductor, switch the test set to the TALK position and blow or whistle into the transmitter of the test set while it is connected between ground and the terminal which you have identified as ring. If you have properly identified the ring conductor, you will hear side-tone in the receiver of the test set, provided you are receiving electrical energy for the talk circuit via the ring conductor. The absence of a loud click or side-tone on either side of the line indicates that a fault exists between the test point and the central office.

After termination. After you have installed the subset and have completed all terminations, you must test the newly installed station for proper operation. Normally, you check the installation for ringing, transmission, reception, and noise. Also, with a dial telephone, you check the dial speed.

Make these operational tests by calling the installation wire chief or, in large installations, the test desk operator. In either case, you complete a standard test after you have made a preliminary check to the switchboard. The preliminary check not only proves that continuity has been established and that the telephone will operate, but it also gives you an opportunity to improve the connection. Then the completion of the ringing, transmission, reception, and noise test with the wire chief will show detailed defects. Remember that a routine call will not accomplish this purpose. In addition to testing both sides of the line for grounds and for foreign voltage, the instruments will indicate whether or not the condenser in the ringing circuit of the telephone subset is properly connected and the subset dial is adjusted for the proper speed.

To perform the tests with the wire chief, you usually start by calling in and reporting that you are ready for a test. The wire chief or the test desk operator then prepares for the test and calls you back. The ringing test is completed automatically when the wire chief calls back. You complete the transmission test by holding the handset in a normal manner and talking in a normal, conversational tone. For this purpose, hold the transmitter directly in front of your mouth so that your lips almost touch the mouthpiece. The reception test is completed when the words received are distinct and understandable. A satisfactory noise test is truly the absence of noise, because a scraping noise indicates that some portion of the installation is wrong. If you hear the scraping noise when no part of the telephone is moving , or when you are blowing into the transmitter, you should replace the transmitter. A scraping noise which changes in volume when you shake the cords indicates that the cord should be tightened.

Remember that youmust find and correct any trouble you noticed during the testing procedures. You will probably find only minor troubles at this time, because most installers can be expected to do workmanlike jobs on the installation. But after these are corrected, you should list the troubles you located on the line record for permanent record.

If your tests show the line and installation to be satisfactory, then you must complete the local communications service order. You are required to confirm the cable pair and terminals used in terminating the station. You must list the apparatus used on the back of the installation work copy. This listing should show whet the equipment and materiel you installed was new or used, what you did with it, and what was connected or changed. Also list any supplementary equipment installed. After this has been done, sign the service order and turn it in through the service foreman to the central office.

Exercises (456):

1. How do you insure that a cable pair you plan to terminate is good into the central office?

2. Give the objective of the test in which you look for the the voltage potential at the telephone line conductors.

3. When determining the line quality, what components should be tested?

4. What conductor is being tested when you hear a loud click in the telephone test set?

5. Compare the test results from a telephone test set when checking tip and ring of a pair.

6. Testwise, what does sidetone indicate?

7. What is the operational test which determines the condition of the DC blocking condenser?

8. Name the operational tests which require that a normal conversation be held.

9. What operational test is being made when you note scratching while blowing into the transmitter?

10. Identify the operational test that must be made when wrong numbers are a continual problem.

11. If there is no dial tone, what is a probable fault?

12. What is the probable fault symptom if the ringing condenser is defective?

13. What is the probable fault if there is noise in the transmitter when the telephone is moved?

14. Tell three tasks that you will do when completing a communications service order.

Preventive Maintenance and Station Trouble Isolation

AS AN INSTALLER specialist, you try to prevent telephone troubles and try to locate those that occur in the subset area. Also, you cooperate with other telephone personnel to locate troubles in the lines, cables, or central office equipment.

Preventive maintenance includes inspection and other work done on equipment to keep it in good working condition so that breakdowns and interruptions in service are held to a minimum. You will normally accomplish preventive maintenance by systematically inspecting the overall installation and then correcting or repairing any defects you find.

The principles and procedures which you use to isolate troubles are not difficult if you study the trouble symptoms and think carefully about them and the circuit involved. Generally, the methods of trouble location in the subset and trouble isolation in the station wiring are similar.

The test sets used for locating troubles in station and drop wiring, in the subsets, and in the lines from the central office operate on similar principles. Thus, our description of test sets in the previous chapter will also apply to the descriptions of this chapter.

This chapter briefly reviews preventive maintenance, corrosion control, fault location and repair of telephone sets, trouble isolation from the central office, trouble location procedures, and trouble elimination.

5-1. Preventive Maintenance

As a telephone equipment installation and repair specialist, you are responsible for the maintenance of telephone sets used on your base or installation. You must be able to maintain these along with their associated circuits and equipment. In other words, you are responsible for the maintenance of the telephone equipment that extends from the terminal of the telephone line or cable through the telephone sets in the installation. This equipment includes the lead-in or drop wiring extending from the terminal on the telephone pole to the building, the protector assembly (for lightning, etc) mounted on the building for lightning, etc. the inside wiring and connecting blocks, and the telephone sets with their associated apparatus.

Since corrosion is a major problem for metals, corrosion prevention and treatment is one of your responsibilities. We'll first look briefly at preventive maintenance.

457. Identify preventive maintenance procedures for specified telephone system equipment.

Preventive Maintenance Tasks and Conditions. As an installation and repair specialist, you may have to perform preventive maintenance inspections on the telephone installations at your base. Furthermore, you must do preventive maintenance while working on other jobs. For example, when you are installing or repairing a telephone set, you must inspect the associated equipment (pole terminals, drop wiring, connecting blocks, etc) and make necessary repairs. Generally speaking, inspect the associated equipment as follows:

Terminals. Examine the wiring and connections at the pole terminals to make sure that all connections are in good condition and that the drop wiring is properly attached to the pole.

Drop wiring. Examine the drop wiring that extends from the pole terminal to the protector block on the building to insure that it is in good condition, properly attached, and has adequate clearance from trees, powerlines, cables, buildings, etc.

Protectors. Examine the protector assembly on the building to make sure that it is grounded, properly attached, and that its protector mechanisms (carbon blocks, fuses, etc) offer maximum protection to the circuit components.

Station wiring. Inspect the station wiring that extends from the protector on the outside of the building to the telephone connecting blocks inside of the building to insure that it is in good condition and properly attached. Also, examine the connecting blocks along the station wiring to insure that they are not broken or damaged.

Exercises (457):

1. State the two primary tasks used for providing preventive maintenance.

2. What condition should you look for in telephone wiring?

3. Identify the condition to look for at a telephone protector.

458. Give reasons for and results of a corrosion control program.

Corrosion. If not controlled, corrosion creates unsafe conditions by causing deterioration of metal in the telephone equipment. This destruction of the metal may prevent the equipment from performing efficiently and could cause a system outage.

Prevention Responsibilities. Corrosion prevention is the responsibility of all telephone system personnel. Commanders must insure compliance with the corrosion control regulations and see that there is an aggressive training program. Staff and crew supervisors must develop a skill-oriented training program, review and update it regularly, assign specialists to participate, and insure there attendance. Each specialist must be familiar with corrosion, recognize the symptoms of its destruction, and know how to report and control it.

We mentioned in the above paragraph that all installation and repair specialists must attend a corrosion training session. This program will review the most recent technical data and provide instructions the approved methods and materials for treating corrosion. A good training program with reliable follow-on inspections of treatment procedures will reduce equipment outages, lengthen the life of the equipment, and eliminate unnecessary equipment replacement costs.

Exercises (458):

1. Give two reasons for a corrosion control program.

2. What is required of a corrosion control program?

3. Describe three results from a good corrosion control program.

459. Consulting figure 5-1 as needed, identify types of corrosion and specify the conditions that indicate metal failure.

Corrosion Types. Most metals try to return to their natural state. Iron rusts, for instance in a moist area. Rust is iron oxide. The environment (temperature, humidity, surrounding materiels, electrical factors) can retard or accelerate the pace of corrosion. Corrosion is either chemical or electrochemical.

Chemical. Destruction of the metal by direct contact with a chemical is chemical corrosion. An example of this type of corrosion is the destruction of the metal battery cable and battery support by battery acid. Other chemicals used at a power van that may cause this type of corrosion are flux and caustic cleaning solutions.

Chemical corrosion may weaken the components, loosen connections, or in the case of the battery cable, make the conductor nonconductive. The appearance of the corrosion varies with the metal. It may be a grey or white powder, a green film, or a red rust on the surface. Then, under this powder, you will see that the surface is pitted or etched. If the surface is left untreated for a length of time, the metal may crack and break.

Electrochemical. You may note electrochemical corrosion at an outside weather location. It is the metal-to-metal contact corrosion you will use at rivets, bolts, screws, terminals, welds, etc. For this corrosion to exist, certain conditions must prevail.

- There must be a metal that corrodes (anode).
- There must be a cause factor (cathode).
- There must be an electrolyte or continuous liquid path (usually moisture and salt or similar contaminant) to conduct a tiny electrical current from the anode to the cathode.

Figure 5-1 illustrates the above three major conditions. The metal of the equipment is an additional element that enables corrosion to exist. This metal also permits electrons to flow from the anode to the cathode.

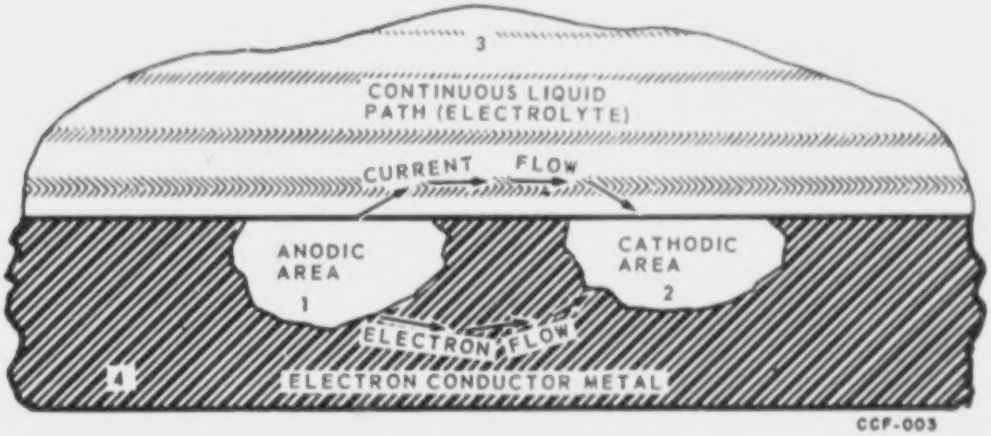

Figure 5-1. Typical corrosion elements.

Symptoms of electrochemical corrosion may be small paint blisters or metal blisters, cracks in the metal following stress (seen after a bolt is torqued), or deep grooves. Another symptom may be a discolored area (may be dark blue, black, or brown) caused by overheating. This darkened area identifies metal that is weakened and thus prone to electrochemical corrosion. The most critical result of corrosion is metal fatigue. Fracture of the metal often occurs prematurely because of this fatigue.

Fungus. Although corrosion is generally considered to be chemical or electrical, fungus is another form of corrosion. It is particularly critical for electrical systems because it attacks wire insulation. Destroyed insulation results in crossed circuits and short circuits.

Exercises (459):

1. Identify the corrosion most probable at the terminals of of a terminal box.

2. Name the corrosion evident at a power van battery cable.

3. Identify the conditions that indicate metal failure.

460. Identify suspect conditions and detection symptoms for corrosion control of telephone equipment.

Corrosion Conditions. Inspect daily for conditions that lead to corrosion and for symptoms of corrosion. Each site has at least one troublesome area where corrosion is always evident despite reliable routine inspections and maintenance. Thus, look for this area and remember to be especially thorough when inspecting the equipment here.

Inspect for those factors which accelerate corrosion, such as high temperature and high humidity, dust, oil, salt water and salt condensation, spilled acids and cleaning solutions, and flux residents. Also, look for deterorioraated seals around equipment drawers, area doors, etc., which permit moisture condensation to increase at the metal surfaces. Pay special attention to possible formation of corrosion when you inspect the terminals, wiring, protectors, etc. This is especially important in damp climates.

Detection Symptoms. Rust and gray or white powder are symptoms of corrosion. Also look for surface blisters, pitting, or etching. Since the most severe deterioration is not at the surface, you will have to disassemble the equipment or use ultrasonic or eddy current test equipment on the equipment that you suspect may be internally corroded to determine its condition. Symptoms of this deterioration are raised layers, cracks, deep grooves, localized abrasions, pressure indentations, and fine debris.

Exercises (460):

1. Identify conditions that lead to corrosion.

2. List three undesirable environmental conditions.

3. Identify two housekeeping tasks that, when done poorly, that may result in corrosion.

4. List four symptoms of corrosion.

461. Using figure 5-2 as appropriate, give corrosion prevention methods and identify treatment procedures.

Corrosion is easier to prevent than it is to cure. A small amount of planning may save hours of labor in troubleshooting and changing instruments.

Prevention. The prevention of corrosion at a substation installation depends largely upon planning the installation of the telephone equipment in such a way that it will withstand the conditions existing at the particular location. Ordinary telephones should not be installed in places where excessive moisture can cause damage. Where moisture does exist, consider the possibility of installing weatherproof apparatus.

All telephone equipment and attachments meant for outside use are protected from corrosion by either zinc or galvanized coatings, or they may be made from metals or materials that will not rust or corrode. Aluminum, copper, plastic, bakelite, and porcelain are frequently used. Equipment used outside is usually made so that weather, rain, snow, hot sun, and winds will neither damage the material nor cause circuit breakdowns during the normal usable life of the item. Normally, if specifications are followed during the installation, there is little danger of corrosion damage to the part of the telephone equipment that is out in the weather. It is the rest of the equipment, the connecting wiring, and inside parts that usually cause the trouble.

To prevent troubles inside of the building or installation, the wiring, terminals, connecting blocks, etc., must be placed so that dampness cannot damage them. Sometimes this may call for a special kind of wire or rerouting the wire to a drier location. The damage to the insulation might not be called corrosion by a strict interpretation, but if the insulation is destroyed, shorts and grounds may occur and cause an interruption to service. Also, if corrosion forms on terminals, not only can it destroy them but, in severe cases, it may cause a short between the connections.

Corrosion can also be controlled by shelters, covers, and containers. This is especially true when the shelters or covers prevent moisture from entering the apparatus. It is important that these methods be used by all personnel concerned. Keep the protection covers in place and replace worn seals.

Treatment. When you find corrosion in a piece of equipment, you will probably have to replace the affected part. This may be the only method available to get the equipment back in operation but, at the time of replacement, possibly you can do something to prevent the recurrence of corrosion. Another type of instrument, moving part of the

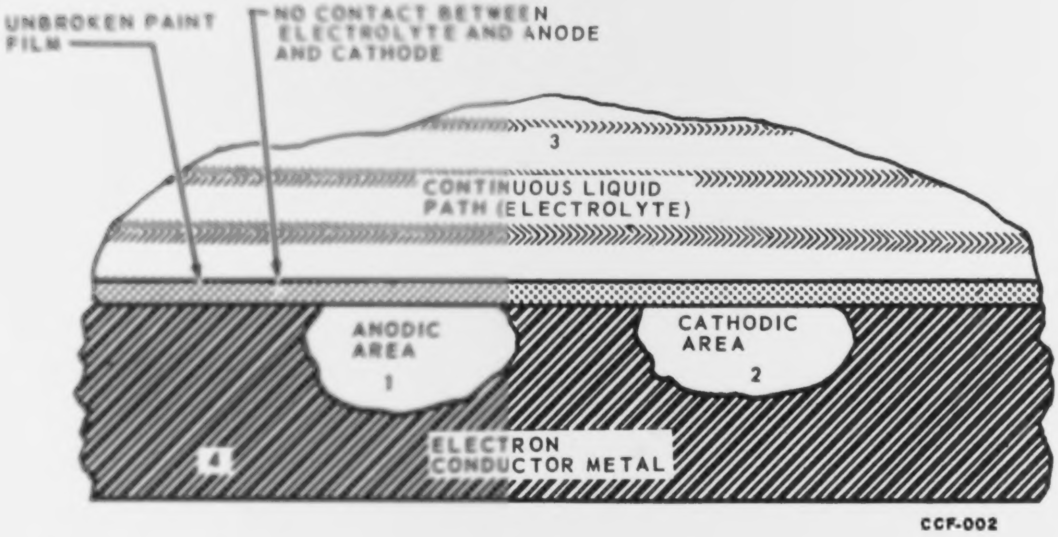
UNBROKEN PAINT FILM
NO CONTACT BETWEEN ELECTROLYTE AND ANODE AND CATHODE
3
CONTINUOUS LIQUID PATH (ELECTROLYTE)
ANODIC AREA
1
CATHODIC AREA
2
4
ELECTRON CONDUCTOR METAL
CCF-002

Figure 5-2. Inhibiting factor to corrosion—illustrated.

equipment, a rerouting of the cable or wire—any of these actions might prevent the same thing from happening again. The piece of equipment that has been damaged by corrosion will need cleaning and adjusting and quite likely will need drying out. To put it back in operating condition, remove all traces of corrosion, rust, and moisture. Also, clean and adjust all of the contact points.

When planning installations and while performing preventive maintenance inspections, remember that prevention is the easiest part of corrosion control. Detection of corrosion is a matter of performing frequent inspections of suspected installations.

Regular cleaning and proper surface refinishing are basic to corrosion control. Remove dirt and debris from the work area and clean all powder, film, chips, and grit from the equipment. Before soldering, grinding, or drilling, protect the surrounding equipment with covers. Remove residual flux from the metal surface near a soldered joint to prevent it from becoming pitted. Use a caustic solution only where authorized and insure that the container for it is tightly capped and that it is not stored near the equipment.

Remove corrosion from surfaces either with pumice paste or by burnishing, wire brushing, grinding, or blasting. You must use discretion when choosing the method and use care when doing the work because you can damage the metal as severely as does the corrosion.

Mix the pumice paste as specified in the regulations and apply it to the surface with a soft cloth. Rub gently. To keep corrosion or metallic debris from building up on the surface area, wipe the area regularly with a clean dry, soft cloth. If corrosion stains remain following the pumice treatment, use grit or abrasive paper and water to clean the surface. Abrade the area; then again wipe the surface with a clean, dry cloth. Your objective is to remove only enough material to eliminate the corrosion and make the surface smooth. Then you can apply the protective finish.

Remember: A brightly polished surface is normally not as resistant to corrosion as a nonpolished surface, unless it is coated with paint or grease.

Figure 5-2 is like figure 5-1 except that it shows a layer of paint between the metal and the electrolyte. As a result, there is no current flow between the anode and cathode. Not all metals can be painted; thus you use grease as the protective coating for them. The type of protection to use, the method by which you apply it, and the metal differences are listed in the corrosion technical order that pertains to your equipment. Use the technical order when treating corrosion. Another important point: If you see frequent or unusually severe corrosion, report it to your supervisor.

Exercises (461):

1. What installation action is most important to prevent corrosion?

2. To reduce or prevent corrosion, what is the primary damaging factor to consider when preparing to install telephone units?

3. Give an important corrosion preventive action to use with key system equipment.

4. Describe the preferred method for removing corrosion.

5. Name two protective finishes for metal surfaces.

5-2. Fault Location and Repair of Telephone Sets.

We noted that corrosion affects metals. Uncontrolled corrosion destroys metals. Damaged metal in a communication circuit may cause a system outage, and when there is a system outage, you must locate its cause and repair the defective unit. There are many other types of telephone troubles, however, than corrosion; your job includes repair of all kinds of repair problems.

The information given in the telephone trouble report is often a clue to the location of the fault. For instance, the subscriber has reported the trouble symptom as "The bell doesn't ring." If no other trouble symptom is listed, and you can talk and receive over the set, there is good reason to believe that the trouble is within the instrument (telephone set). The probabl causes for troubles in telephone sets are listed in troubleshooting charts for the telephones concerned. As an installer-specialist you should have access to telephone troubleshooting charts at your station of assignment.

462. Correlate telephone repair procedures with the workers who make such repairs.

We have said that if you study the information on the service order, work order, etc., it will help you to find the trouble at the subset location. The information on the form usually includes the location of the telephone set, the wire or cable pair involved, the telephone number, the trouble reported, and in many cases, its probable location. As you analyze the information on this form, you may find that a schematic diagram will help you to localize the trouble in the subset area. In every case, make a visual inspection of the wiring and connections. Remember, this visual inspection is very important, since it may disclose the cause of the trouble.

Touble Location. By careful analysis of the trouble report and by line testing you may isolate the trouble to the telephone set. Replacing the telephone set with another is usually the quickest means of restoring service. However, if you can restore service more quickly by repairing the faulty telephone set, do so.

The telephone subset is not the only place in the system where trouble may develop. For example, if a telephone subset is in perfect operating order but fails to operate in the system, then the trouble is somewhere in the station wiring, the telephone cable or line, or in the central office.

General Procedures. Before testing any of the subset circuits, test at the aerial cable terminal, or, in large buildings that are so equipped, test at the telephone terminal cabinet. The wire chief will have identified the proper terminals for the circut; therefore, the test at these terminals is to determine that the source of trouble does not lie on the central office side of the equipment. If the trouble is on the central office side, you should report it to the wire chief, but still check the subset to determine its working condition. Test the subset by contacting the central office and requesting the wire chief to furnish the terminal numbers of a spare pair. You can do this by using a test set like the one shown in figure 4-26. To do this simply connect the test set to the terminals of a good pair and call the central office. In a dial system you must use a test set dial to dial the number of the test desk.

When the pair is assigned, connect the test handset across the spare terminals to determine whether or not that pair is good. Then connect the telephone set to be tested to the new terminals, call the test desk, and request that the test desk operator run a transmission test on the telephone. If a regular test desk is not available, the wire chief can make the transmission test from a test board. The wire chief should also test the ringer by signaling over the line.

If any of the above tests indicate that the trouble is in the substation, follow these specific procedures to isolate theproblem. Before you test the subset equipment, test the inside wiring (wiring inside the building extending from the connecting block to where the telephone wire enters the building) by removing the cover from the connecting block and disconnecting the leads from the telephone. Connect the test handset across the terminals on the connecting block and call the test desk. If you find defective inside wiring, replace it without attempting to determine the exact location of the trouble.

We have already referred in general to the wire chief's test desk and to the necessity for conferring with the wire chief during troubleshooting procedures. The wire chief plays an important part in another way in the location of substation troubles. Before you are dispatched to troubleshoot a circuit, the wire chief determines the general situation. For instance, he or she will be able to tell you the type of service (dial or manual), the type of equipment, and the effect of the trouble on the telephone user's service.

Once telephone sets have been installed, maintenance consists mostly of locating troubles and making the necessary repairs. Troubles in telephone sets or circuits are indicated by the fact that some part of the subset or circuit is not functioning properly. Symptoms of trouble indicate failure or malfunction of any one of the four operations of the telephone set: (1) signaling the operator or seizing the automatic switching equipment, (2) receiving the ringing signal, (3) transmitting sound, and (4) receiving sound.

Frequently, more than one factor may be causing the trouble in the subset. Consequently, you should follow a thorough step-by-step procedure to localize and eliminate each source of trouble. Be sure that you follow these procedures to completion even though the immediate cause of trouble has been discovered in one of the earlier steps, because you might find dirty connections or points of probable breakdown which could develop later into serious trouble.

Telephone trouble may sometimes result from failure of the telephone user to handle the instrument properly. If such is the case, you should instruct the user in proper telephoning techniques, however, you should still test the general operating condition of the equipment.

Exercise (462):

1. Match telephone workers in column B with their appropriate job responsibilities in column A. Each letter will be used more than once.

463. List telephone set tests, and identify basic troubleshooting symptoms and procedures.

Preliminary Testing Procedures. There are three basic procedures to follow when you are troubleshooting a telephone set: (1) Make an operational check to determine which circuit in the set is not operating properly. (2) Make a visual inspection of the set to discover any obvious faults, such as opens caused by broken wires or connections, shorts caused by improper contacts between spade clips, and improper mechanical action caused by the presence of foreign materials. (3) When the trouble is not obvious enough to be seen during the visual check, make a continuity test to determine if the circuit under test is complete.

After you have eliminated any troubles between the pole terminal and the telephone, you should perform operational tests to isolate the trouble in the telephone set. These tests are basically the same as the initial tests performed at the time of telephone installation. Briefly, to perform these tests first inspect the external parts of the telephone, such as the handset, handset cord, mounting cord, telephone housing, and dial assembly. During this inspection, you should verify that the dial does not bind and that the hookswitch mechanism operates freely. When the inspection is completed, there are two tests you must perform (1) the transmission test and (2) the signaling test.

Transmission test. To perform the transmission test, first lift the receiver and listen for dial tone. Next, blow gently into the transmitter and listen for sidetone in the receiver. While blowing in the transmitter, move the dial slightly off normal. Sidetone in the receiver should be cut off by this action. After checking for sidetone, dial the number of the wire chief, operator, or a local telephone set. You should hear no dial clicks in the receiver while dialing and the ringer bells should not tap. Then carry on a conversation with whoever answers you call, noting how well both voices are heard during a normal conversation. Also blow gently into the transmitter during the conversation and note whether you hear any scratching or sizzling noises. While the conversation is still in progress, shake, twist, and stretch the handset and mounting cords to see if any scratching or sizzling noises are heard. Noises indicate that these cords are in poor condition. If the above tests are unsatisfactory, either repair or replace the telephone, depending on the nature of the trouble. If all of the tests are satisfactory, proceed with the signaling test.

Signaling test. To perform the signaling test, dial the ring-back number (if the central office is so equipped); otherwise, ask the wire chief or operator to ring the telephone under test while you observe the operation of the ringer or bells. The bells should ring clearly and at the proper volume. Also, while the signaling test is being made, move the volume control (loudness control lever) from the highest position to the lowest position and note whether the volume change is appropriate.

Exercises (463):

1. What is the first basic troubleshooting procedure to make to determine if a telephone is performing satisfactorily?

2. Identify two of the telephone set tests you must make that will disclose the condition of the instrument.

3. Give the troubleshooting procedure that discloses open circuits, loose connections, corrosion, binding contacts, etc.

4. Specify the troubleshooting procedure in which you use test equipment to determine that the basic circuits are complete.

5. Identify five basic actions you perform during a transmission test.

6. List three trouble symptoms that may be noted during a transmission test.

464. Cite telephone set trouble symptoms and isolation tests.

If you see no broken wires or connections, you may then make continuity, voltage, and resistance measurements with the proper instruments, using a systematic process of elimination. You can thus locate troubles in a minimum amount of time. Start this check from a point in the circuit that you know is good. Then check and eliminate successive parts of the circuit until you locate the fault.

Fault Isolation. If the telephone set does not operate properly during the above tests, it may be best to install another set and take the old one to the shop for additional inspections and tests. But, if you have plenty of time and it is not too urgent that service be established immediately, it may be easier to isolate the trouble while the set is still installed. At least by using the telephone test set, you should be able to localize the trouble to one of the five basic circuits of the telephone set. These basic circuits are: the ringing, talking, receiving, dialing, and the short-on-line circuits.

To do this with a telephone test set, you must open the telephone and connect the clips of the hand test set, with the switch in MON (MONITOR) position, across the telephone line at the subset terminals. This places the test set in a position that allows you to monitor the operation of the subset during a test situation.

With the hand test set connected across the line terminals as explained above, you can determine the trouble symptoms and circuit at fault as follows:

a. Remove the handset from its cradle on the telephone subset and then listen to the receivers of both the telephone and the hand test set. If you hear nothing in either receiver, the symptom is said to be a "No dial tone (NDT) situation."

On troubleshooting charts, this indicates trouble in the short-on-line circuit—which could be either a short or an open in the line circuit through the telephone.

b. With the handset still off its cradle while you are listening to both receivers, hearing dial tone in the receiver of the test set and nothing in the receiver of the telephone indicates a "Cannot hear (CH) situation." This further indicates that the trouble is in the receiving circuit.

c. Next, with the handset off its cradle, operate the subset dial while listening to both receivers. If you hear dial tone in the receiver of the test set and also hear it between digits in the receiver of the subset, you have a "Cannot break dial tone (CBD) condition." This further indicates that the trouble is in the dialing circuit. Also, if you hear nothing in the receiver of the telephone set after the dialing is started and you hear hesitant or distorted dial pulses in the receiver of the test set, it indicates a "Cannot dial (CD) condition." This also indicates trouble in the dialing circuit.

d. Next, with the handset on its cradle and a ringing condition on the line, if you hear the ringing generator in the receiver of the test set and there is no ringing of the telephone, it indicates a "Bell does not ring (BDR) condition." This indicates trouble in the ringing circuit.

e. Finally, if you hear nothing in either receiver when someone is talking into the transmitter with the handset off its cradle, it indicates a "Cannot be heard (CBH) situation." This localizes the trouble as being in the talking circuit.

If the trouble is isolated to one of the five circuits during the tests, you can perhaps pinpoint the trouble within that circuit by studying the schematic diagram for the telephone and circuit. In any event, if you take the subset to the shop for repair, you will have to use the diagrams to trace and test the telephone circuits and components. For the purpose of this text, let's assume that you will replace the subset and repair the old one in the shop.

Exercises (464):

1. Identify three tests for a telephone trouble.

2. Identify two trouble symptoms you may note when monitoring with a hand test set.

3. Name two troubles that may cause a "Cannot hear" symptom.

465. Given telephone set units to be inspected, name associated devices to check and conditions to look for.

When a telephone is brought into the shop for repair, you should thoroughly inspect it before beginning any repair tasks. (Of course, in some cases, you may inspect the telephone at the subscriber's office or residence, but when you have isolated a trouble to the telephone, it is best in the majority of cases to replace the unit and bring the old one in for inspection and repair.) Start your inspection of the subset by examining all of its major components.

Handset inspection. To inspect the entire handset, remove the receiver and transmitter units. Turn the transmitter and receiver caps in a counterclockwise direction to remove them. When hand pressure is insufficient to unscrew the caps, use the tool provided for the F-type handset. This tool is normally not used on the later model (G-type) handsets. When this tool is not available, or the handset is a model on which the tool cannot be used, apply a few layers of friction tape around the cap to get a better grip for its removal. After the caps are unscrewed, remove the transmitter and receiver units and perform the following inspections.

a. Inspect the caps and handset case for chips, cracks, damaged threads, and distorted contacts. If any of these parts are damaged, replace them as needed.

b. Inspect the transmitter unit to see if it is bent or distorted or if the diaphragm is punctured, dirty, or wet. If the unit is defective in any way, replace it.

c. Inspect the receiver unit for dents, dust, and moisture. Clean and test the unit when required. If defective, replace the unit.

d. Examine the handset cord and wiring for frayed insulation near its connections, and check connections for good condition and tightness.

Ringer inspection. To inspect the ringer or any of the internal parts of the subset, remove the telephone housing. After you have remove the housing, inspect the ringer as follows:

a. Examine the ringer assembly for secure mounting, make sure that the gongs are not loose, and that you can the move the loudness control lever freely.

b. Inspect the ringer coils for nicks, dents, and loose connections. Test the ringer coils as described in the section on testing.

c. Examine the biasing spring; if it is broken or lacks tension, you must replace the ringer assembly.

Hookswitch inspection. In general, inspect the hookswitch in the following manner:

a. Inspect springs for bent or rusty condition and for pitted contacts. Make sure that the contacts make and break properly.

b. Test for free lever action. If the mechanism squeaks or binds, it is defective.

c. When the spring pileup is defective, you may replace it on some telephone sets, but on others, you must replace the entire set.

Check with your source of supply and read pertinent technical orders to determine which parts are available for replacement.

Induction coil inspection. When the telephone set has an induction coil that is not part of a network, inspect it in the following manner:

a. Inspect the induction coil for secure mounting and make sure that all of the wiring connections are tight and in good condition.

b. Inspect the windings for nicks, dents, and breaks. Replace the coil assembly if it is damaged.

c. If the coil appears to be in good condition, test the resistance of the windings as explained in the tests section.

Network inspection. If the subset is equipped with a network assembly, inspect the network as follows:

a. Inspect the assembly for dents, chips, and broken terminals. Examine all wire connections and tighten loose terminals.

b. If there is any doubt about the network, test its windings as explained in the test section.

Housing inspection. Inspect the housing for cracked, chipped, or discolored condition. Check the padded feet on the base to insure that they will not damage or mar desk finish.

Dial inspection. Inspect the telephone dial in the following manner.

a. Examine the dial for secure mounting and tighten any loose screws.

b. Inspect the finger stop and finger wheel for loose or bent condition and examine the number card for cleanliness, tears, and legibility. Replace any damaged parts by following the instructions in the pertinent technical order.

c. Insure that all wire connections are tight, and test the dial for proper operation, including the testing for proper dial speed. This must be done by following the instructions for the dial test equipment used in your organization.

Cord inspection. Inspect the handset and mounting cords for cut or frayed insulation and for poor connections or loose cord stays. Also, test the cords for continuity, as we will explain later in circuit testing.

Capacitor inspection. When the telephone uses capacitors that are not contained in a network, inspect them in the following manner:

a. Inspect the capacitor case for dents, cracks, or leaking fluid. If it is damaged in any way, replace it.

b. Examine and tighten wire connections as necessary.

c. Test the capacitor if a capacitor test set is available.

Exercise (465):

1. Match the telephone units of column B with their devices and defects in column A. Each unit will be used more than once.

Column A
Devices and Defects

____ (1) Loose gongs.
____ (2) Squeaking movable parts.
____ (3) Leaking fluids.
____ (4) Diaphragm puncture.
____ (5) Cap damage.
____ (6) Open conductor.
____ (7) Binding.
____ (8) Dent, dust and moisture.
____ (9) Cracks and chips.
____ (10) Slow speed.
____ (11) Missing feet.
____ (12) Loose connections.
____ (13) Rust.
____ (14) Frayed insulation.
____ (15) Improper winding resistance.
____ (16) Broken bias spring.
____ (17) Pitted contacts.
____ (18) Broken terminals.

Column B
Telephone Unit

a. Handset.
b. Induction coil.
c. Network.
d. Telephone housing.
e. Dial.
f. Handset cord.
g. Ringer.
h. Hookswitch.
i. Telephone cord.
j. Capacitor.
k. Transmitter.
l. Receiver.

466. Given units to be tested or sample test information, specify applicable tests and probable test results.

We will only consider the principles involved in testing telephone components and circuits. We will use some representative circuits to show the use of a telephone test receiver or click set. Before we discuss these tests, however, we wish to point out that the same type of continuity tests may be performed on any telephone circuit simply by using the wiring diagram (for the specific telephone) to trace out the circuit and establish the test points. You can also make similar continuity tests while using either the telephone test set or the multimeter.

Testing Telephone Components. Before testing a component, you must inspect it to make sure that it has no broken leads or dirty, corroded terminals that will interfere with the tests. Also, study the schematic diagram of the circuit to see if any of the connected leads will affect the test. If the apparatus connected to a component interferes with the tests, disconnect the wiring. You'll do the tests explained in the following paragraphs while using the multimeter with its function switch in the OHMS position. Of course you must remember that the scale to be used (R × 1, R × 10, etc.) depends upon the amount of resistance to be measured. In any event, the reading will normally be more accurate when you use scale that causes the meter to read in the lower half of the scale during the measurement. Now consider the testing of some telephone components.

Induction coil. To test the induction coil, you must measure the resistance of each winding. If the values vary more than 10 percent from the amounts specified when you test the windings of the 101A inductor coil, the coil is defective. The values specified for the windings of the 101A induction coil are as follows: The resistance value of the primary winding is 22 ohms; the value given for the secondary winding is 19 ohms; and that for the tertiary winding is 75 ohms.

Network. The 425B network is used with the 500-type telephone as well as with many other telephones. To test the resistance in the components of this network, you must make three measurements as follows: (1) The resistance measured between network terminals R and RR should read 135 ohms. (2) The resistance measured between terminals R and GN should be 83 ohms. (3) The resistance between terminals B and C should be 39 ohms. Remember that because this network also contains capacitors, it may still be defective even when the resistance values are satisfactory.

Ringers. Test the ringer windings by measuring the resistance of each coil. If any value varies more than 10 percent from that specified, the coil is defective. Since there are many types of ringers and bells used, you must look up the values specified for the ringer being tested. Always look up the resistance values for *any* unit you are testing. Don't try to remember specifications.

Receiver. The resistance of a receiving unit should not vary more than 10 percent from that listed for the specific unit. Again, always look up the specifications for the unit being measured. The values for the U1 and HA1 receivers are as follows: The U1 receiver (used in the G-type handset) should have a resistance of about 12.5 ohms and the HA1 receiver (used in the F-type handset) should have a resistance of about 24.5 ohms.

Transmitter. Since the resistance of a transmitter is variable, testing it with an ohmmeter is not very reliable. If you have reason to believe that the transmitter is defective, replace it on a temporary basis with one that you know is good and continue with the troubleshooting procedures.

Dial. The dial, of course, does not have specified resistance values, but you can check the operation of its contacts by using either the telephone test set or the multimeter. By connecting across the dial contacts, you can check them for continuity when they are closed and for breaking the circuit when they are open.

Capacitors. When a regular condenser tester is not available, you can check a ringing or talking capacitor with an ohmmeter in the following manner.

a. Disconnect the capacitor leads from their terminals.

b. With the ohmmeter set on its high-resistance scale, connect its leads across the terminals to charge the capacitor.

c. Reverse the leads and touch the capacitor terminal; the ohmmeter should show a momentary deflection (kick) as the capacitor discharges and then recharges in the opposite direction.

d. Reverse the leads (back to the first position) and again touch them to the capacitor terminals. The ohmmeter should again show a momentary deflection as the capacitor discharges.

e. If the capacitor will not load up and discharge in both directions (as indicated by deflections on the meter), replace the capacitor with one that is known to be in good condition.

Exercises (466):

1. Name the two tests to be made when the PSM–6 function switch is selected to OHMS and the range switch is at R × 1.

2. Assume that you're testing a good 101A induction coil with a PSM–6 and the range switch is selected to R × 10,000. What reading will you probably note?

3. The specified resistance value for the primary winding of the 101A induction coil is 22 ohms. If its primary winding measures 20 ohms should you consider such a coil to be defective? Why?

4. What measurement should you get when testing a 500-type telephone network between terminals R and RR with a multimeter?

5. What test equipment should you use to test the telephone ring circuit devices, and what results should you expect?

6. Cite the meter to use and the expected results for the dial contact test.

467. Given examples of transmitter and receiver circuits, specify components, testing connections, and results of typical tests.

To cover the general principles of telephone circuit testing we will explain continuity checking of transmitter and receiver circuit in the following paragraphs.

Testing the Transmitter Circuit. Assuming that the telephone can neither transmit nor receive, you must check the transmitter circuit before you check the receiver circuit While studying the transmitter circuit, refer to the simpli diagram shown in figure 5-3. Note that the RED lead has been disconnected from the R terminal of the induction coil and th a test receiver and battery are connected to the RED lead. This point of connection is identified with the letter A in the illustration, and it is one of the test points used in all of the transmitter tests. Touch the other test lead to points B, C, D, and E as you continue the testing. Before we consider the transmitter tests any further, let us examine the circuit components between points A and B in figure 5-3. You can see that a RED lead extends from test point A to the RED terminal on the handset. Also note that a black (BLK) lead extends from test point B to the BLK terminal on the handset.

Although it is not shown as such in figure 5-3, we assume that the telephone transmitter is connected between terminals BLK and RED in the handset. The transmitter, as you may recall, makes contact with these terminals through spring contacts in the handset. With the transmitter in place in the handset, the circuit should be complete from test point A to point B. To test this circuit, connect the test receiver from point A to B and then blow or talk in the handset transmitter as you listen to the test receiver. If the sound comes through the test receiver satisfactorily, the circuit from point A to point B is all right. However, if the sound does not come through the test receiver, the transmitter or one of the connecting leads (RED and BLK) is defective. When this is the case, test the transmitter and each lead separately to determine which is at fault.

When the test shows that the circuit from test point A to test point B is functioning properly, the transmitter and its leads are not at fault. To perform the next test, then, move one test lead from test point B to test point C. This connects the test receiver from point A to point C and allows us to test for continuity through the dial pulsing contacts between points B and C by blowing or talking in the transmitter. If this

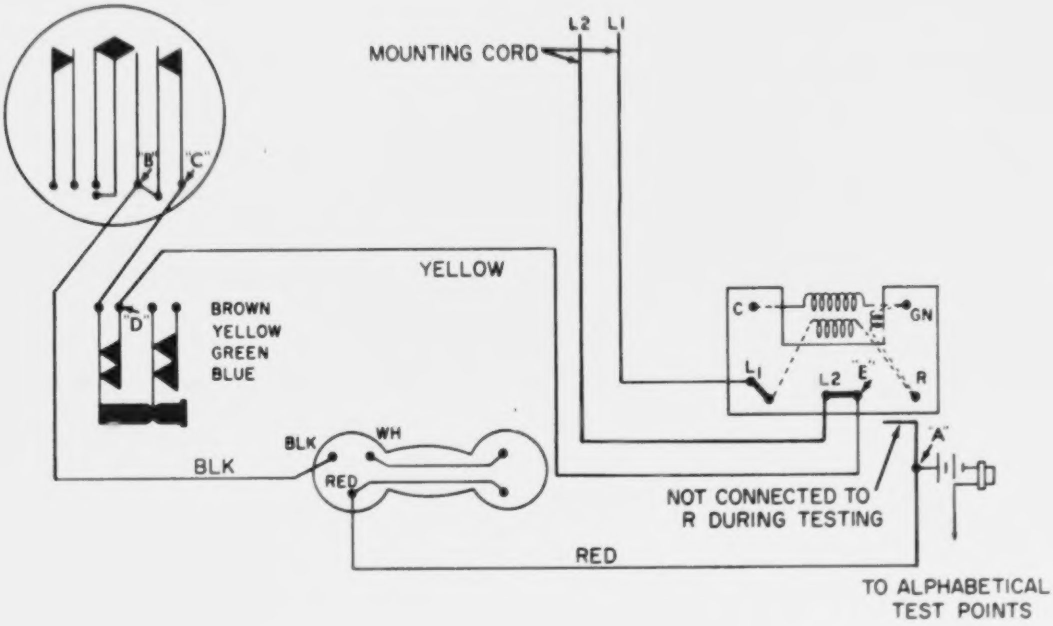

Figure 5-3. Transmit test.

test is satisfactory, move the test lead to point D to test the continuity of the hookswitch contacts between points C and D. If the hookswitch contacts are satisfactory, move the test lead to point E to test the yellow lead which extends from the hookswitch to the induction coil. If these tests prove to be satisfactory, you can assume that the transmitter circuit is functioning properly. The next test then is that of the receiver circuit.

Testing the Receiver Circuit. The receiver circuit tests are illustrated in figure 5-4. When you check this circuit, you determine test results by the clicks you hear in the telephone receiver only. Pay no attention to the clicks heard in the test receiver. Also, these receiver tests are performed only after you know the phone transmits. Again the A position is the test set's lead at the disconnected wire of the R terminal, but the B, C, D, and E positions are not the same as those used for testing the transmitter circuit.

Before we discuss the receiver tests, examine the circuit between points A and B in figure 5-4. You can see that a RED lead extends from point A to the terminal RED on the handset. Also, note that conductors extending through the handset connect the WHITE and RED terminals to two receiver terminals at the opposite end of the handset. Although it is not shown in the illustration, the receiver unit (when in place in the handset) completes the circuit between these two terminals. Thus, when the receiving unit is in place in the handset, the circuit should be completed from point A to point B via the RED and WHITE leads and the handset receiver. If this circuit is in good condition, connecting the test leads from point A to point B causes a click in the handset receiver. If you do not hear a click when you make this test, it indicates that the circuit between points A and B is at fault. When this is the case, test the leads and the receiver individually to locate the faulty unit.

When the test indicates that the circuit is in good condition between points A and B, move the test connection from point B to point C. This extends the test through the dial and hookswitch contacts, shown between points B and C in figure 5-4. If you hear a click in the handset receiver during this test, the circuit is in good condition from point A to point C. However, if this test does not produce a click in the receiver, the circuit between points B and C is at fault. (This assumes, of course, that the previous test showed the circuit from point A to point B to be in satisfactory tory condition.) To continue the test, move the lead to point D, thus testing the green lead and induction coil winding between points C and D. If this is satisfactory, move the lead to point E to test the leads and capacitor between points D and E. Once again, when a test indicates that the circuit is faulty between two test points, then you must individually test the components between these two test points to locate the faulty unit.

Exercises (467):

1. What component is tested when you follow the check at test point B with the test at point C? (See text fig. 5-3.)

2. What test points shown in text figure 5-3 are checked to determine the condition of the strap at induction coil L2?

3. When testing a transmitter circuit such as the one shown in figure 5-3 of the text, what is indicated if the test from point A to point C is satisfactory, but sound does not come through the test receiver while testing from point A to point D?

4. When testing a receiver circuit such as the one shown in figure 5-4 of the text, what is indicated if you don't hear a click while testing from point A to point B?

5. When testing a receiver circuit such as the one shown in figure 5-4 of the text, what is indicated if you don't hear a click when the test receiver with its battery is connected directly across the terminals of the handset receiver?

468. Cite typical repair procedures for specified telephone subset components.

Telephone Set Repair. Since the parts of the telephone subset have different functions, conditions will affect each part differently. To illustrate, an operating component, such as the dial, should have more troubles than would a stationary unit like the terminal board. Let's now consider the dial, the hookswitch, and ringer repair.

Dial troubles and adjustments. Before we discuss the troubles and adjustment of dials, let's review the actions of the dial and their effects on the telephone circuit. You can see in the circuits of figures 5-3 and 5-4 that the receiver and transmitter circuits are wired in series to the hookswitch and the dial pulsing springs (spring contacts between points B and C in fig. 5-3). These pulsing springs are normally closed. They open only while the dial is returning to normal after a number has been dialed. They open and close during this period the same number of times as the digit dialed. For example, if the number dialed is 6, these pulsing springs open and close six times in order to transmit six electrical impulses to the central office. To keep these pulses from being heard in the receiver as clicks, the receiver is made inoperative during the dialing period by the dial shunting springs, which either open the receiver circuit or short it out, depending on the type of dial used. Furthermore, some dials have additional shunting springs to increase the strength of the electrical impulses. Their action decreases the resistance of the telephone by shorting out the transmitter or the transmitter and a portion of the induction coil when the dial is not in the normal rest position.

Dial speed is an important factor in the operation of the telephone system. If dial speed is improperly adjusted, the subscriber will get wrong numbers from a correct dialing procedure. With most systems the proper speed is 10 pulses per second, though it can vary slightly and still be effective. A dial speed tester permits you to check the speed accurately. There are various types of dial speed testers on the market, and you should use each type in accordance with the instructions furnished by the manufacturer. If no test set is available, test the speed by stating in an ordinary conversational way the words "one thousand and one," while letting the dial return to its normal position from 0 position of the finger plate. Since it takes approximately 1 second to say this phrase, the dial should stop just as you say "one" at the end of the phrase.

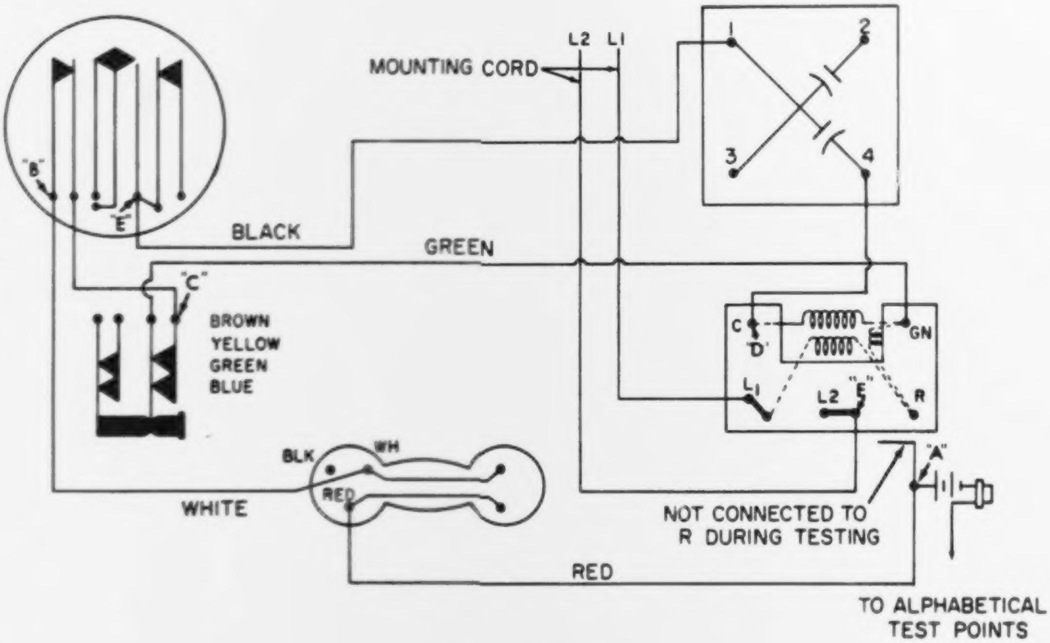

Figure 5-4. Receiver test.

The location of dial troubles is comparatively simple but varies with different types of dials. Generally, when looking for dial faults, you check the cleanliness and condition of the spring contacts, see that the moving parts operate properly, and check all wires attached to the dial to make sure that they are tight and not shorting out.

The dial should require no lubrication for several years. However, under extremely dry circumstances or dusty conditions, the bearing surfaces may need lubrication in order to continue their smooth mechanical performance. If it becomes necessary to lubricate the dial, use an approved dial lubricant only. Also, wipe the excess oil from all dial surfaces, as the oil tends to collect dirt. Furthermore, keep oil away from the internal parts of the governor drum. One final statement about the dial—if a replacement unit is available, is probably best to replace the dial assembly whenever it malfunctions.

Hookswitch maintenance. The hookswitch used with the modern subset is illustrated in Volume 2, Chapter 2, along with the 500-type telephone. This switch is semipermanently mounted on the telephone base with rivets. The contacts are protected with a plastic cover that is easily removed when necessary. Normally, no adjustment or attention other than cleaning is ever needed on this switch. With other types of hookswitches, however, you may have to adjust the contacts or even replace the switch assembly.

To maintain or check out the hookswitch on any telephone, you must first understand the operation of its contacts. In many cases you must learn the various contact positions by looking at the wiring diagram for the telephone concerned. All telephones, however, have certain similarities in the operation of their hookswitches. One operation common to all telephones is that when the handset is placed on its cradle, the hookswitch contacts must disconnect the telephone circuitry (except for the ringer) from the telephone line. Also, when the handset is removed from its cradle, these contacts must connect the telephone circuitry to the line. In addition to the line contacts on the hookswitch, there are other contacts that function in various ways. For example, there are contacts on some hookswitches that disconnect the ringer from the line when the handset is removed from its cradle and reconnect it when the handset is replaced on its cradle. Also, the receiver circuit is disabled on some telephones when the handset is placed on the cradle, and it is reestablished when the handset is removed from the cradle.

When tests indicate that the hookswitch is not functioning properly, if the assembly is replaceable, it is usually best to replace it. When the hookswitch is not replaceable, replace the subset if you cannot correct the malfunction. In some cases, however, especially when the operating parts are binding, it may be possible to free the mechanism by a small amount of lubrication. If you try this, be sure to keep the lubricant off the hookswitch contacts.

Ringer maintenance. The ringer in the common-battery telephone (either dial or manual) is connected through a capacitor which blocks the direct current and passes the ringing current. It is necessary to block the DC; otherwise there would be a permanent signal on the switchboard at the common-battery central office. Normally this capacitor gives very little trouble.

On the ringer assembly, one of the two gongs is movable and the other is fixed. The vibration frequency of the two gongs differs to provide a combined effect more pleasing to the ear, and to allow for changing the output for people whose hearing is impaired in the higher frequency range. Up to the point of ringer burnout, the ringer will not suffer demagnetization from line surges due to lightning or accidental contact with powerlines. The ringer coil, coil core, and gongs are the only parts of the ringer that may be replaced at any maintenance level. Do not remove the ringer coil, however, unless facilities are available to remagnetize the permanent magnet. When the ringer magnet loses its magnetism, the bell will not ring until the magnet is recharged. Replace the entire ringer as a unit whenever you find it defective.

Transmitter and receiver maintenance. We have discussed the testing of transmitting and receiving circuits. When such tests show that either one of these units is defective, is is best to replace the defective item with a new or reclaimed unit.

Instrument cords. The tips of the cords and the conductors near the tips usually suffer the greatest damage from normal wear and from rough and careless handling. For this reason, they require regular and close inspections. When the cord or its tips are defective, replace the cord assembly.

Touch-tone equipment. Inspect, test and repair those keyset components which compare to the regular telephone in the same manner as we described in the previous pages. To illustrate, you inspect the handset for chips and damaged threads, the transmitter and receiver for dirt and damage, the hookswitch for free lever action and pitted contacts, etc. In this subset you must also inspect the dial pushbuttons for free movement. Do not attempt to repair the electronic units at the station. Install another telephone set and take the faulty set to the shop for maintenance.

Exercises (468):

1. When the dial assembly is not functioning properly, what is the best method for correcting the trouble?

2. If the line loop is not opened by the telephone hookswitch, what is the probable corrective procedure?

3. When the ringer is defective on the modern telephone, what is the normal method of repair?

4. If a touch-tone telephone has a broken cord tip, what is the normal corrective procedure?

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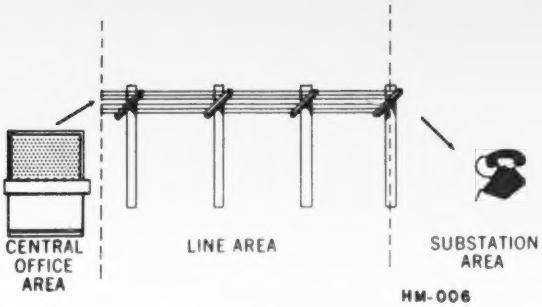

Figure 5-5. Trouble locations.

5-3. Trouble Isolation from the Central Office

When trouble develops in telephone circuits, the central office is immediately affected. The problem then is the responsibility of the wire chief, who must determine if the trouble is in the central office or in the circuit to the substation and who must assign a specialist to correct the trouble wherever it may be.

469. Identify telephone system trouble locations, faults, and tests performed by the wire chief or test desk operator.

In general, the three possible trouble locations are, as shown by figure 5-5, in the central office, on the line, or in the substation. Although troubles at the various points are not identical, they are mostly common electrical faults such as opens, crosses, shorts, and grounds. You will determine the proper method of isolating each after tracing the faults to their probable locations.

The wire chief selects the sets to use and considers these basic troubleshooting factors: (1) the type of service, whether dial or manual; (2) the type of apparatus, according to the line and substation characteristics; (3) the weather conditions at the time the trouble was reported; and (4) the history of the equipment, which may provide a clue to the present trouble.

The wire chief not only must have the basic know-how but also must complete various tests from the central office. One of these, a telephone transmission test, tests the condition of the substation transmitter and receiver, provided the substation is not completely out of order.

In a large central office, a test desk may be available (see fig. 5-6). This single-position test cabinet is equipped to test dial or manual telephone station lines (both inside and outside the central office), outside plant wiring, and dial telephone substation equipment. The desk contains a volt-ohm-milliammeter, a dial speed indicator, a Wheatstone bridge, dry-cell test batteries, and various test trunk circuit apparatus and controls.

The operator operates the test desk by using two rows of lever switches on the switch shelf and five push switches, which are associated with the out-call wires, located at the left of the lever switches. Remember, since a test desk is complicated, it requires a trained operator to make the tests. Usually, the wire chief or the central office test desk operator performs the task. Table 5-1 summarizes the tests which can be made from the test desk. The Varley and Murray loop methods are similar to the bridge test methods discussed in Chapter 4 of this course.

From the results of the tests, the test desk operator can usually determine the approximate location of the trouble. If it appears that the trouble is in the subset area, will be sent to the scene. If it appears that the trouble is in a line or cable, the operator dispatches line and cable personnel to isolate and repair the fault. In some cases when the trouble is in a line or cable pair, you may be sent to change the termination of a subset over to a good pair. When the trouble is in the subset area, you must run a series of tests to determine its exact location and, after having located the trouble, correct it.

Exercises (469):

1. In what location is improper dial speed a fault?

2. A splice fault is most probable in what telephone system location?

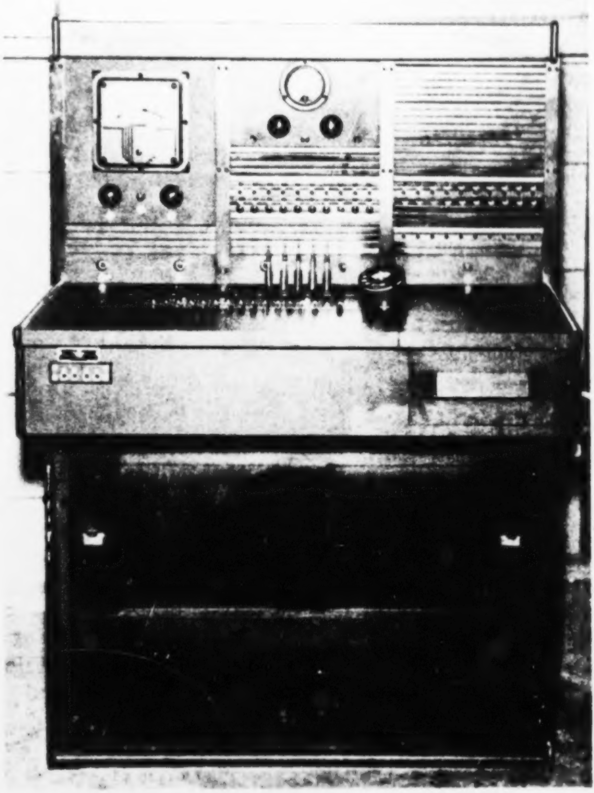

Figure 5-6. Type No. 1 test deck.

TABLE 5–1

POSSIBLE TESTS FROM TEST DESK

Volt-Ohm-Milliammeter

1. Loop circuit tests, transmission test, and insulation breakdown test.
2. Ground on ring (−) side of the line.
3. Ground on tip (+) side of the line.
4. Loop resistance.
5. Insulation leakage.
6. Negative potential on the ring (−) side of the line.
7. Positive potential on the ring (−) side of the line.
8. Negative potential on the tip (+) side of the line.
9. Positive potential on the tip (+) side of the line.
10. Checking the voltage of the test batteries.
11. Transmission test.
12. Line equipment bridge test.
13. Capacitance of station ringer capacitors.

Ringing and Miscellaneous Tests

1. Ringing on bridged single-party line.
2. Loop resistance tests and fault-locating measurements.

Auxiliary Test Cord Circuit Tests

1. Ringing over individual or two-party lines.
2. Dial speed and pulse ratio (percent make) tests on dial station lines.
3. Sounder and tone tests on lines to identify cable pairs.
4. To connect the howler to station lines.

Sounder Cord Circuit Tests

1. Identifying pairs or conductors in the cable by short-circuiting or grounding the conductors.
2. Identifying pairs or conductors in a cable by connecting a receiver across the conductor.
3. Identifying pairs or conductors in a cable by opening the circuits or removing ground.

Wheatstone Bridge Tests

1. Loop resistance test.
2. Measuring the distance to a ground on a line by the resistance method.
3. Measuring the distance to a fault on a line by the two-wire Varley loop method.
4. Measuring the distance to a fault on a line by the Murray loop method.
5. Locating a fault on a line by the three-Varley method, using three wires.
6. Any other desired Wheatstone bridge tests requiring two or three wires.

3. A test desk fault is most probable in what telephone location?

4. Cite four probable telephone system faults.

5. Name the test performed by the desk test operator to determine the condition of the telephone station handset components.

6. Cite a test desk test performed by the test desk operator to determine telephon line resistance.

5-4. Trouble location Procedures

In locating faults in the drop, block, and station wiring, you can save much time and effort by careful analysis and systematic procedures. In some instances you can readily detect the probable location of a fault by a visual inspection of the line. At other times, this visual inspection may reveal the trouble symptoms which should help you analyze the circuits to detect the probable fault.

470. Given common electrical troubles, cite symptoms and probable causes.

Before proceeding to the station, have the test desk operator give you information on the probable nature of the fault and the cable pair and terminal numbers associated with the faulty circuit. Then go directly to the vicinity from which trouble was reported and make a visual inspection for obvious breaks, damaged insulation, and proper terminal connection.

The common telephone wire conditions are opens, shorts, crosses, or grounds, as shown in figure 5-7; and they, in turn, result from such obvious causes as those tabulated in table 5-2.

Fault Descriptions. Remember that the line conductors in a telephone circuit are classified as tip and ring. The ring conductor, or negative side of the line, supplies the electrical energy for the talking circuit; the tip conductor provides the return path for the current to the central office ground, thereby completing the talking circuit. When testing circuits and locating faults, you will frequently have to identify these tip and ring conductors.

Opens. An open exists when the conducting circuit is broken. It is possible to have situations where the circuit is open intermittently. Therefore, opens are classified as "complete opens" or "intermittent opens." Sometimes, high-resistance connections (connections where poor contact is made) are classified as opens. Below are additional faults that commonly cause opens in drop, block, or station wiring:

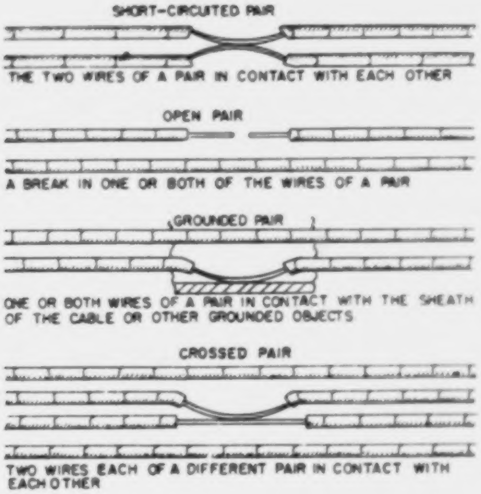
SHORT-CIRCUITED PAIR
THE TWO WIRES OF A PAIR IN CONTACT WITH EACH OTHER
OPEN PAIR
A BREAK IN ONE OR BOTH OF THE WIRES OF A PAIR
GROUNDED PAIR
ONE OR BOTH WIRES OF A PAIR IN CONTACT WITH THE SHEATH OF THE CABLE OR OTHER GROUNDED OBJECTS
CROSSED PAIR
TWO WIRES EACH OF A DIFFERENT PAIR IN CONTACT WITH EACH OTHER

Figure 5–7. Substation trouble causes.

a. A wire disconnected from a terminal.

b. An improper or split pair connection at a cable terminal.

c. A loose connection at a terminal.

d. An improperly made splice.

e. A high-resistance connection caused by the formation of corrosion on the conductors, binding posts, nuts, or terminals.

A line open causes the telephone set to be dead. By this we mean that ringing and talking are not possible. Normally, the telephone user reports this line condition, since an open line circuit appears good at the central office.

Shorts. A short may exist at any piece of apparatus or portion of the circuit. You may refer to a circuit as being partially or completely shorted. For example, a shorted ringer capacitor in a subset would only partially short the line circuit, but a short from tip to ring of the drop wire would completely short the line circuit. Shorts are often caused by a drop wire with broken insulation; a clamp conducting from one conductor to the other; cable rings wearing through the cable sheath and conductor insulation; high voltage hitting the cable pair, welding the conductors together; and moisture accumulation in terminals, protectors, or connecting blocks.

A completely shorted circuit causes the telephone subset to appear dead because of the reduced resistance that the short offers to the circuit. A partial short affects the individual apparatus in parallel with it, but the rest of the circuit may be unaffected.

Crosses. A circuit "cross" is the term used to describe the situation when a conductor from one line pair makes contact with a conductor from another pair. A cross may be caused directly by contact between adjacent conductors or indirectly through equipment in the central office. There are four types of crosses that can occur in telephone work: ring-tip, tip-ring, tip-tip, and ring-ring, each indicating trouble in the form of ground or foreign voltage. Crosses are caused by the same defects as shorts—moisture, tips too long, broken insulation, and other conditions.

a. Ring-tip. The ring-tip cross means that the ring conductor of one pair is in contact with the tip conductor of another pair. In this case, ground will be indicated on the ring conductor concerned. The reason for this is that all tip conductors are normally grounded. Therefore, the cross connection between ring and tip extends ground to the ring conductor. When the ring conductor is on the pair reported as defective (the pair which you are troubleshooting), the symptoms of trouble in this pair are (1) a permanent signal at the central office, (2) the telephone subset on this pair cannot

TABLE 5–2

COMMON CAUSES OF WIRE TROUBLES

Causes of Opens

1. Wiring broken by excessive bending or twisting.
2. Bullets piercing a wire.
3. Kinks and nicks in the wire, causing the conductors to break.
4. Poor splices pulling out under tension.
5. Inside wiring nails driven too far into the insulation, breaking the conductors.
6. Loose or dirty connections and lugs.
7. Blown, broken, or badly warped fuses.
8. Defects in the manufacture of the wire.
9. Excessive strain on the wire at the terminals, causing conductors to become loose.
10. Sharp or heavy objects striking a wire, causing a break.

Causes of Shorts

1. A drop wire swinging against an object, wearing off the insulation, and causing the two conductors to make contact. (This is called a swinging short.)
2. A break in the insualtion of a drop wire at the drop clamp, with the clamp serving as the connector between the two conductors.
3. Water settling on an old deteriorated drop wire and acting as a conductor. (This is called a wet short.)
4. Dirty fact plates on terminal cans serving as a conductor between the two lugs assigned to a pair.
5. Wiring at any point of termination extending too far and contacting another lug.
6. Inside wiring nails driven through the insulation so that the metal nailhead causes contact to be made between the two conductors.

Causes of Grounds

1. Bare conductors of a worn drop wire making contact with any grounded metallic object.
2. Wet or worn inside wiring making contact with grounded metallic object.
3. A broken bridge at the terminal can making contact with the terminal, cable stub, etc.

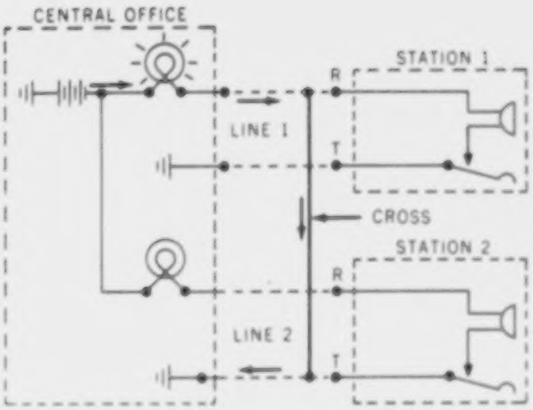

Figure 5-8. Ring-tip cross.

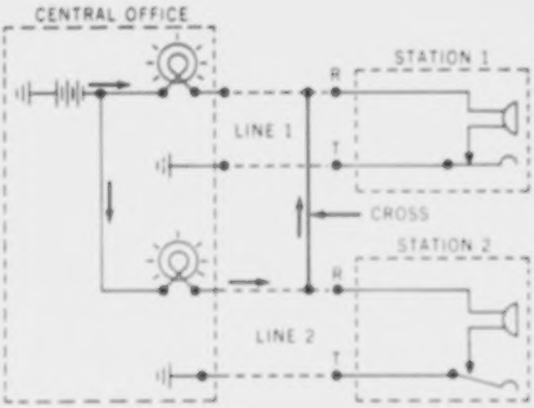

Figure 5-10. Ring-ring cross.

receive or transmit or can do so only with difficulty, and (3) crosstalk (talk from the other pair concerned) is heard if both lines are in operation at the same time. The exact effect on the telephone subset is determined by the location of the cross. Because of the permanent signal, the central office personnel would most likely report the trouble. The ring-tip cross is illustrated in figure 5-8 by the line and arrows which indicate a connection from the ring conductor of line 1 to the tip conductor of line 2. By looking at this illustration, you can see how this cross completes a circuit through the central office battery, lighting the signal lamp for line 1 in the central office.

b. Tip-ring. The tip-ring cross illustrated in figure 5-9, is very similar to the ring-tip cross. As a matter of fact, the only difference in the situation between the circuits illustrated in figures 5-8 and 5-9 is that the condition between the lines has been reversed. That is, if you were troubleshooting line 1 in figure 5-8, you would be dealing with a ring-tip cross, and if you were troubleshooting line 1 in figure 5-9, you would be dealing with a tip-ring cross. If the station 1 attendant for figure 5-9 had noted the trouble, crosstalk would most likely have been reported. This type of cross, however, would light the lamp in the central office for line 2. Therefore, the central office personnel report the trouble as being in line 2. From these reports and by performing tests, you can determine the approximate location of the cross.

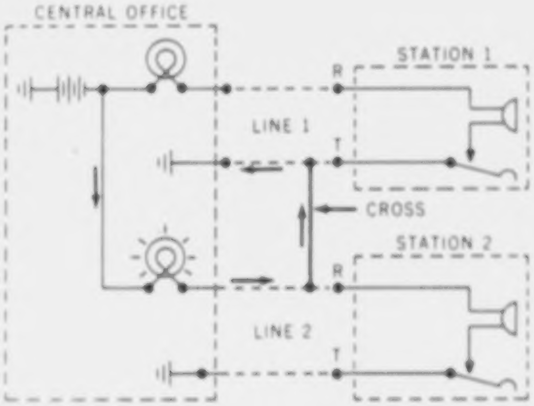

Figure 5-9. Tip-ring cross.

c. Tip-to-tip. A tip-to-tip cross does not affect the central office switchboard, and it causes crosstalk only when both lines are operating at the same time. Therefore, this trouble may exist for several days before it is noticed or reported by the telephone subscriber station personnel.

d. Ring-to-ring. A ring-to-ring cross between the ring conductors of adjacent pairs causes a false signal on one line when a station is operating. You can see in figure 5-10 that the line lamps in both circuits will operate when the hookswitch at either station is closed. You can also see that the hookswitch in station 1 is closed and the one in station 2 is open. The results would be the same, however, if the hookswitch in station 2 were closed and the one in station 1 were open. When ringing current is sent to either station, it rings the bells of both telephone sets. A ring-ring cross may be reported by either the telephone station or central office personnel.

Grounds. A line ground is an undesirable connection to earth or to conductors which are connected to earth. Most grounds occur at telephone set protectors, where the carbon blocks make contact when high voltage flashes across the 0.0003-inch airgap. Foreign particles, such as dust and moisture, often settle between the carbon blocks and establish a conducting circuit to ground. Line grounds, other than those at protectors, are usually the result of damaged insulation which permits the conductors to contact poles, trees, buildings, ground wires, projections, etc. Also, such grounds may be caused by wet station wiring which makes contact to a grounded metallic object.

The effects of line grounds are dependent upon the type of ground. You may see three grounded conditions on a line. The tip side of the line or the ring side of the line may be grounded, or a ground may be on both sides which, in effect, is a direct short. The tip side ground may cause noise in the receiver as a result of AC ground return, power ground return, and the earth currents being introduced into the line. Telephone station personnel usually report these noisy conditions. A grounded ring conductor on the line results in a permanent signal at the central office and prevents transmission or signaling by the telephone station. As a result of the permanent signal, central office personnel usually report this trouble. The ground on both sides of the line causes a complete disruption of service; no signal or transmission is possible and a permanent signal is seen at the central office switchboard.

It is as possible to have intermittent shorts, crosses, and grounds, as it is to have intermittent opens. These intermittent effects are referred to as "swinging" grounds, shorts, etc., while the completely shorted or grounded circuit is often referred to as a "solid" short or ground.

It is impossible to overestimate the value of a good understanding of the different types of line faults. It is not unusual for a worker who knows the common causes of line faults and is familiar with the installation to go directly to the cause of a reported trouble upon being told the type of fault in a circuit.

Exercise (470):

1. Match the faults of column B with the causes and symptoms of column A. Each fault will be used more than once.

Column A
Causes and Symptoms

____ (1) Moisture on terminals.
____ (2) Caused by too little slack in cable.
____ (3) High-voltage connection.
____ (4) Permanent signal at central office.
____ (5) Noisy receiving.
____ (6) Metal-to-metal contact between tip wires.
____ (7) Crosstalk.
____ (8) Infinite resistance.
____ (9) Bells ring at transmitting and receiving stations.
____ (10) Drop wire swinging against trees.
____ (11) No audible signaling.
____ (12) Conductor tips too long.
____ (13) False signal.
____ (14) Cable ring insulation damage.

Column B
Faults

a. Ground.
b. Short.
c. Open.
d. Tip-ring cross.
e. Ring-tip cross.
f. Tip-to-tip cross.
g. Ring-to-ring cross.
h. Intermittent problems.

471. State typical information needed when preparing to test for telephone line troubles.

The best way to locate shorts, grounds, opens, or crosses between the terminal and the telephone subset is by using a test set of some kind. Normally, you use the hand test set for testing station lines; however, the type of fault (open, short, cross, or ground) determines how you use the set. Before we consider the testing for each type of fault, let us briefly discuss a required preliminary step required.

Preliminary Step. Before starting a test in the subset area you should have the following information in order to proceed intelligently and efficiently to locate the cause of trouble:

a. The telephone number.

b. The location of the set, given in sufficient detail to permit ready identification of the premises (such as the floor, room number, etc.).

c. Cable number, pair number, and terminal.

d. The pole number on which the drop wires terminate (on other than cable lines) if available.

e. Transmission quality, if any.

f. Nature of the trouble as diagnosed by test or from a report.

g. Whether or not the station is out of service.

h. Other items of special information such as: (1) Any indication that foreign current is on the line? (2) Is the service at fault for a hospital or doctor's office? (3) Has that trouble or a similar one occurred recently on the same line? (4) Should the entire line from the terminal to the station be inspected?

Exercises (471):

1. List three necessary numbers when preparing to test for line faults.

2. Give another location identification not included in exercise 1 that is needed when preparing to test for line faults.

3. What are typical trouble symptoms you should note before beginning a telephone line test?

4. Give an important factor to consider when preparing to begin a telephone trouble repair.

472. Cite test procedures for isolating given faults.

Test Procedures. You first step in locating line faults is to verify the information you were given. Take nothing for granted; always check the line to be sure that the trouble is as reported. Your next step is to determine whether the trouble is in the cable or in the installation wiring. If the fault is in the cable, report the condition to the wire chief or test desk. Another pair may be assigned for the circuit. If the trouble is in the installation wiring, determine the part of the wiring which contains the fault. This procedure of elimination is sometimes referred to as "trouble isolation."

Conductor identification. Although the procedure for identifying conductors was mentioned earlier in this volume, we will provide a more complete explanation in the following paragraphs of how to do this with a hand test set. While reading the steps below, refer to figure 5-11, which shows the test set connected at the cable terminal.

a. Select a convenient test point, such as the cable terminal, the connecting block, or a station protector, where a suitable electrical ground is available.

b. Clip one lead of the test set to the ground.

c. Touch the other lead of the test set alternately to the two terminals at the test location. As each terminal is touched, you should hear a click in the receiver of the test set. The click on the ring (battery) side will be distinct and clearly

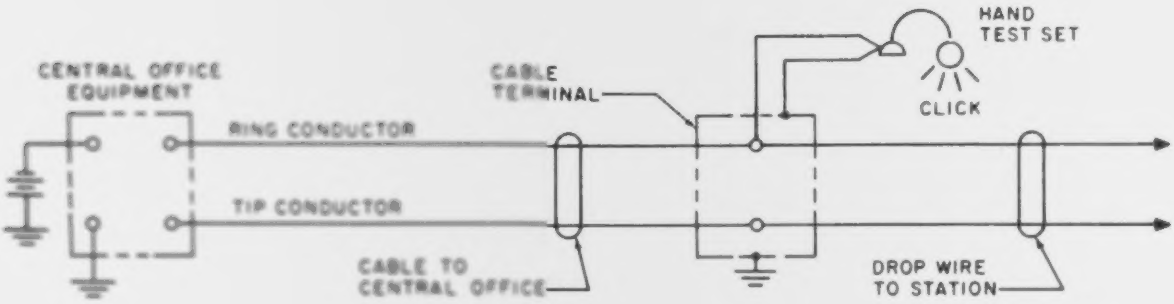

Figure 5-11. Use of hand test set for wire identification.

audible, whereas the click on the tip side will be faint and may not actually be heard, depending on the difference in potential between the central office ground and the ground at the test location. The absence of a loud click or sidetone on either side of the line is an indication that a fault exists between the test point and the central office.

d. Place the test set switch in the TALK position.

e. Check for proper identification of the ring conductor by blowing or whistling in the transmitter of the hand set while the test set lead is touched or connected to the ring side of the line. If the identification is correct, you will hear sidetone in the receiver of the hand set.

Now, let's consider the subscriber's loop isolation test. To carry out this procedure, make the first test at the station protector and then proceed in the direction of the trouble to the next convenient test point. Figure 5-12 illustrates typical test points.

Subscriber's loop isolation. Assume that there is a line fault between the central office and the telephone. Use the following steps in isolating.

a. Remove the fuses from the protector and test back toward the central office (D toward F). If the test indicates the trouble to be between D and F, proceed from the protector to terminal E.

b. Now, remove the drop wire from the terminal binding posts and test toward the central office again (E to F). If E to F is clear of trouble, the fault must be in the drop wire.

NOTE: If in making the first test at the protector (step 1), you find the trouble to be in the station wiring, replace the fuses in the protector and proceed to connecting block A.

c. Remove the line from the connecting block and test back toward the station protector (A to C). If the line is good, the fault lies in the instrument or cords. However, if the line from A to C out as tests faulty, the trouble is in the station run.

You can just as well start the testing process at the terminal as of the station protector, but select points where you can make disconnections readily, such as binding posts, bridging connectors, connecting block, etc. In general, do not cut any wires until the tests have isolated the fault between two adjacent points. Then, after you've inspected at the test points, cut one conductor of the wire to make the test. It is wise to start your testing at the most convenient place; you might save one trip up the pole if you start at the protector. Remember, too, a quick inspection for broken wires is always advisable before beginning the tests. The test set across the tip and ring of the line should respond with a click each time the connection is made and broken. The absence of a click indicates an open in the line.

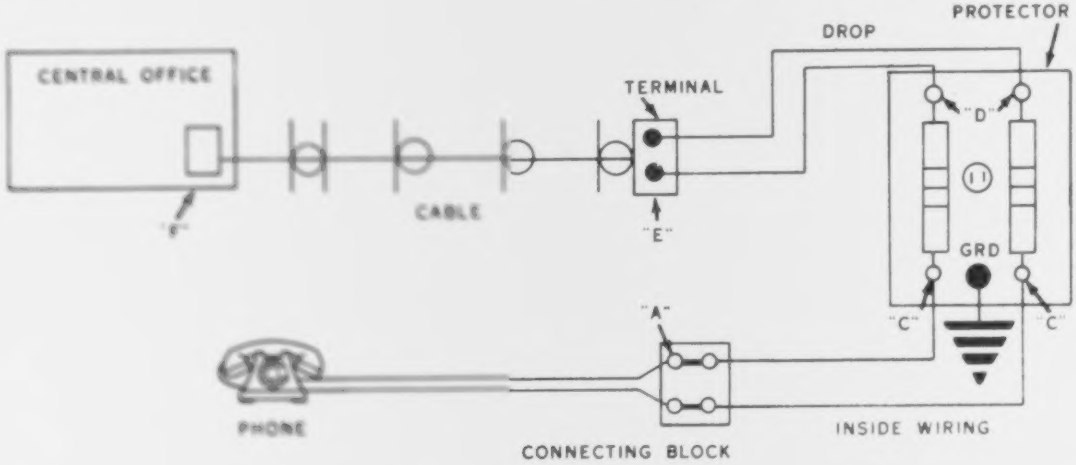

Figure 5-12. Subscriber's loop, test points.

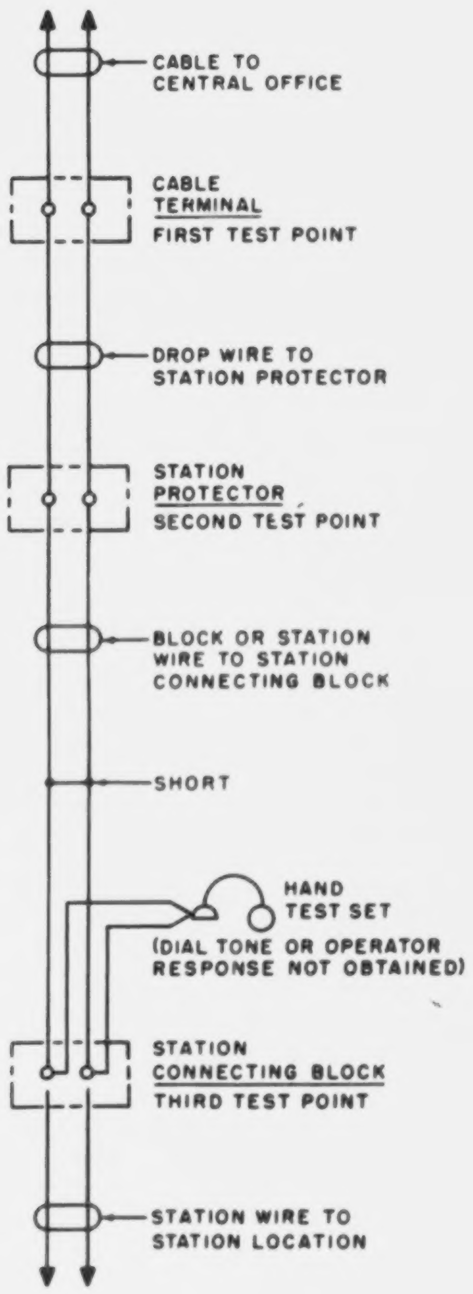
CABLE TO CENTRAL OFFICE
CABLE TERMINAL
FIRST TEST POINT
DROP WIRE TO STATION PROTECTOR
STATION PROTECTOR
SECOND TEST POINT
BLOCK OR STATION WIRE TO STATION CONNECTING BLOCK
SHORT
HAND TEST SET
(DIAL TONE OR OPERATOR RESPONSE NOT OBTAINED)
STATION CONNECTING BLOCK
THIRD TEST POINT
STATION WIRE TO STATION LOCATION

Figure 5-13. Use of hand test set for isolating troubles.

Testing for shorts. As mentioned before, shorts in drop, block, or station wiring are caused mainly by damage to the insulation when the wires are in contact with supporting fixtures, pole or building attachments, and trees or other obstructions along the wire route. Shorts are also caused by dirt or foreign material that has accumulated in terminals, protectors, and connecting blocks. Shorts caused by dirt in terminals and at other interconnections and those caused by dampness penetrating damaged insulation are usually high-resistance shorts which can be more readily detected in wet weather, because then they are usually more pronounced.

The procedure for isolating shorts is the same both high-resistance and low-resistance shorts. With resistance shorts, however, the test desk operator, using central office test equipment, can more accurately guide and direct you to the location of the fault.

To isolate a shorted section of the drop and station wiring installation, test the line at the cable terminal and at successive terminating points. You can start at the cable terminal and work toward the station end of line (fig. 5-13); however, many experienced technicians start at the protector. Use a hand test set to make each test as follows:

a. Disconnect the wire leading toward the station.

b. Bridge the test set leads across the terminals.

c. Listen in the test set receiver for either dial tone or operator response.

If you hear the operator or dial tone, consider the line good up to the test point. Now reconnect the wire leading toward the station end of the line and proceed to the next test point. If you don't hear dial tone or operator response at any test point, the short is in the section of line between that test point and the previous test point. You may then further isolate the short by a close visual inspection to locate the probable defect in the wiring or by cutting the wire at selected points and conducting further tests with the hand test set. If the line is old or the tested section is short, it is common practice to replace the whole section.

When the test at the cable terminal indicates that the short is in the cable, report to the test desk operator for further instructions.

Testing for grounds. Grounds in drop, block, and station wiring are usually caused by damage to the insulation when the wires are in contact with poles, trees, guys, buildings, cables, ground wires, rainspouts, building projections, or other structures.

To isolate the section of the line in which the ground is located, test the line at the cable terminal and at successive terminal points along the line. Start at the cable terminal and work toward the station end of the line. Use a hand test set (see fig. 5-14) to make each test as follows:

a. Disconnect the station leads of the line under test from the terminal post at the test location.

b. Identify the ring side of the line.

c. Clip one of the test set leads to the terminal post on the ring side of the line.

d. Touch the free lead of the test set to each of the disconnected leads in turn.

e. Listen in the receiver of the test set for a battery click on the make and break of each contact.

A battery click on the make and break of either of the test contacts indicates that a ground on the station side of the test point has completed a path for current from the central office battery to ground.

A battery click on the make and break of any of the test contacts at any test point indicates that the ground is in the section of the line between that test point and the previous

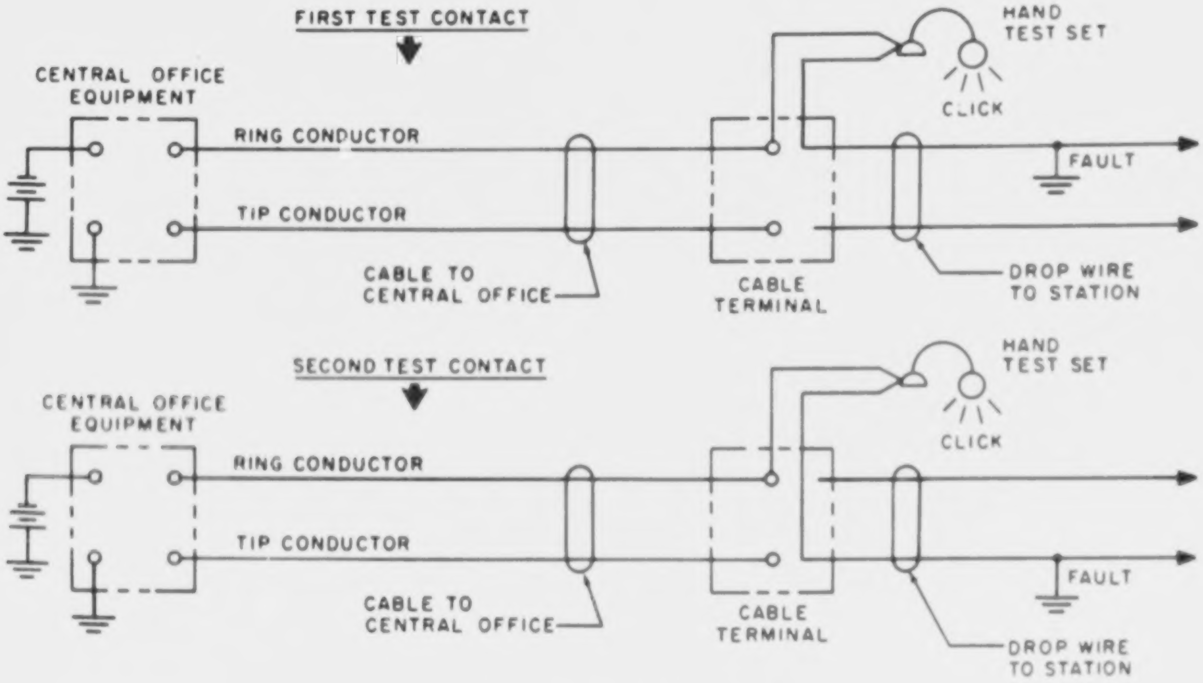

Figure 5–14. Test points for isolating ground.

test point. If you do not hear a battery click during tests conducted at a cable terminal and you cannot trace the ground to a faulty condition in the terminal, then you must assume that the fault is in the cable, and you should contact the test desk operator for further instructions.

Sometimes you cannot isolate high-resistance grounds with the hand test set, so have the test desk operator test the line while you make disconnections at the various terminal points.

After the ground has been isolated to one section of the substation, you may further isolate it with a close visual inspection or with more tests.

Testing for opens. To isolate the section of line in which the open is located, test the line at the cable terminal and at successive terminal points along the line, starting at the cable terminal and working toward the station end of the line. Make each test by bridging a hand test set across the terminals of the circuit under test and listening for a battery click in the receiver of the test set (fig. 5-15). As in previous tests, if you don't hear a click, the open is between the test point and the previous test point. If you do not hear a battery click during tests at a cable terminal and you cannot trace the open to a faulty connection in the terminal, you can assume that the fault is in the cable. In such a case, contact the desk operator for further instructions.

To isolate an intermittent open, move and shake the wires in the section of the line that is on the central office side of the test location. A succession of battery clicks or a fluttering noise in the receiver of the test set indicates that the open is in the section of the line under test. If you cannot isolate the fault by such action, a careful visual inspection of the line, particularly at terminal point connections, will usually disclose the faulty condition.

High-resistance connections are usually caused by improper cleaning of the conductors at terminals or by the formation of corrosion on the conductors, binding posts, nuts, or washers resistance connections, bridge the test set across the conductors or the station side of the termination and listen for noise. If you cannot definitely isolate the fault to any specific connection, disconnect, clean, and reconnect the conductors at all terminal points and retest the line.

Again, after you have isolated an open to one section of the drop or station wire plant, you may isolate it further with a close visual inspection or with additional tests.

The repair procedure you select often determines whether there is a need for further isolation. For inatance, you may decide to use a spare pair rather than isolate the specific fault in an open cable pair.

Testing for crosses. Figure 5-16 shows all four types of crosses that can occur in telephone circuits and the test set connection for each cross that results in an audible response. To make any of these tests, you must disconnect both wires for one of the crossed lines at the terminal binding posts. Place these wires in the position where they can be properly reconnected upon completion of the tests. After the wires have been disconnected, clip one of the test set leads to one binding post, as shown in figure 5-16. Then, clip the other test lead to the disconnected wires in turn. If a click occurs, you can see that the wire causing the click is crossed with another line and the cross is near the point where you are

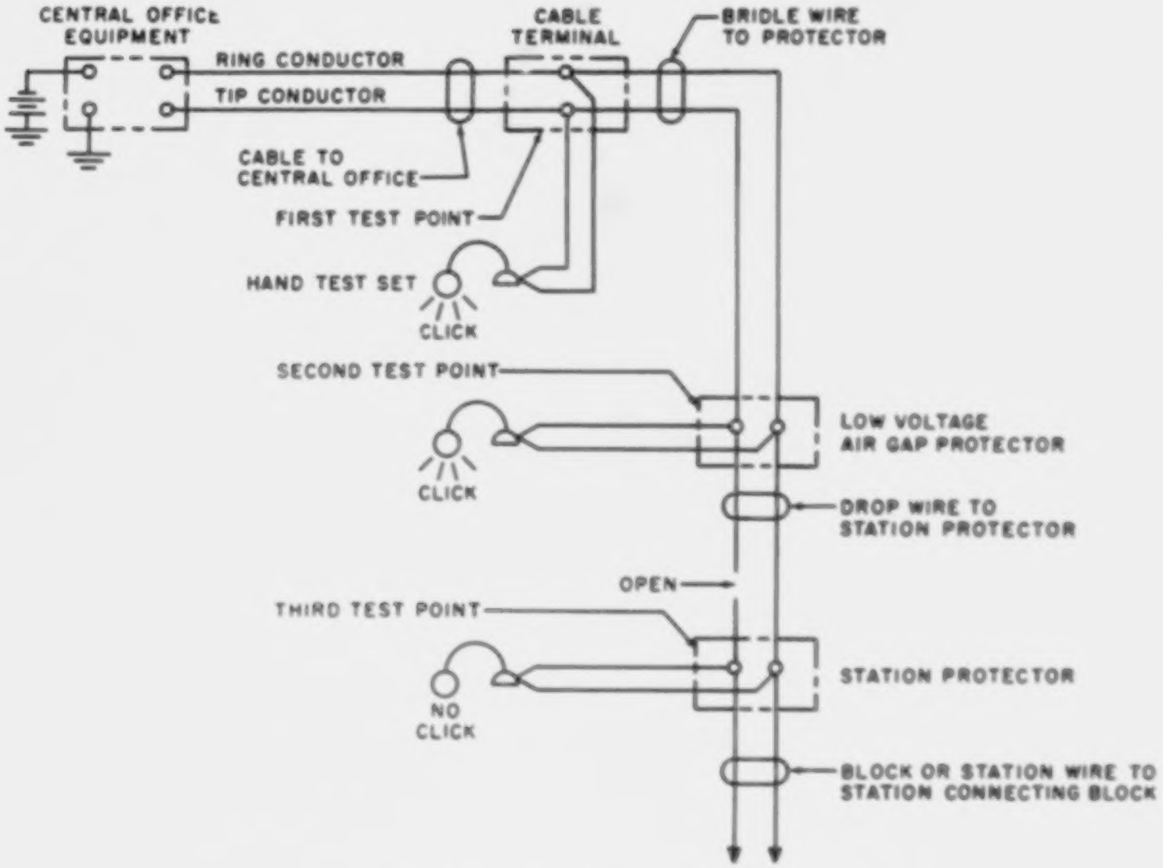
CENTRAL OFFICE EQUIPMENT
CABLE TERMINAL
BRIDLE WIRE TO PROTECTOR
RING CONDUCTOR
TIP CONDUCTOR
CABLE TO CENTRAL OFFICE
FIRST TEST POINT
HAND TEST SET
CLICK
SECOND TEST POINT
LOW VOLTAGE AIR GAP PROTECTOR
CLICK
DROP WIRE TO STATION PROTECTOR
OPEN
THIRD TEST POINT
STATION PROTECTOR
NO CLICK
BLOCK OR STATION WIRE TO STATION CONNECTING BLOCK

Figure 5-15. Test points for isolating an open.

making the check. If there is no click, then transfer one test clip to the other binding post and repeat the test by again touching the other test clip to the disconnected wires. If you hear no clicks for either test, the cross is not in this part of the circuit.

Testing for a cross in a cable containing several pairs may sometimes be rather deceiving. What appears to be a crossed circuit may actually be a short. Remember that a cross involves two circuits or two pairs. The click that you hear when testing may be caused by either of two conditions: the pairs may be shorted or the line under test may be crossed with an adjacent pair. Performing both cross and short tests, you can usually isolate the trouble effectively.

Exercises (472):

1. What is the preferred method for determining and locating a telephone line fault?

2. If a test at the central office shows the proper potentials yet the test at the building protector shows incorrect potentials, what should be your next test point? (See text fig. 5-12.)

3. For a hand test set, what indication will you note at the TIP and RING terminals when the telephone line pair is normal?

4. For a hand test set, what indication will you note at the TIP and RING terminals when the telephone line pair is open?

5. What is the first procedure when checking for a short-circuited line?

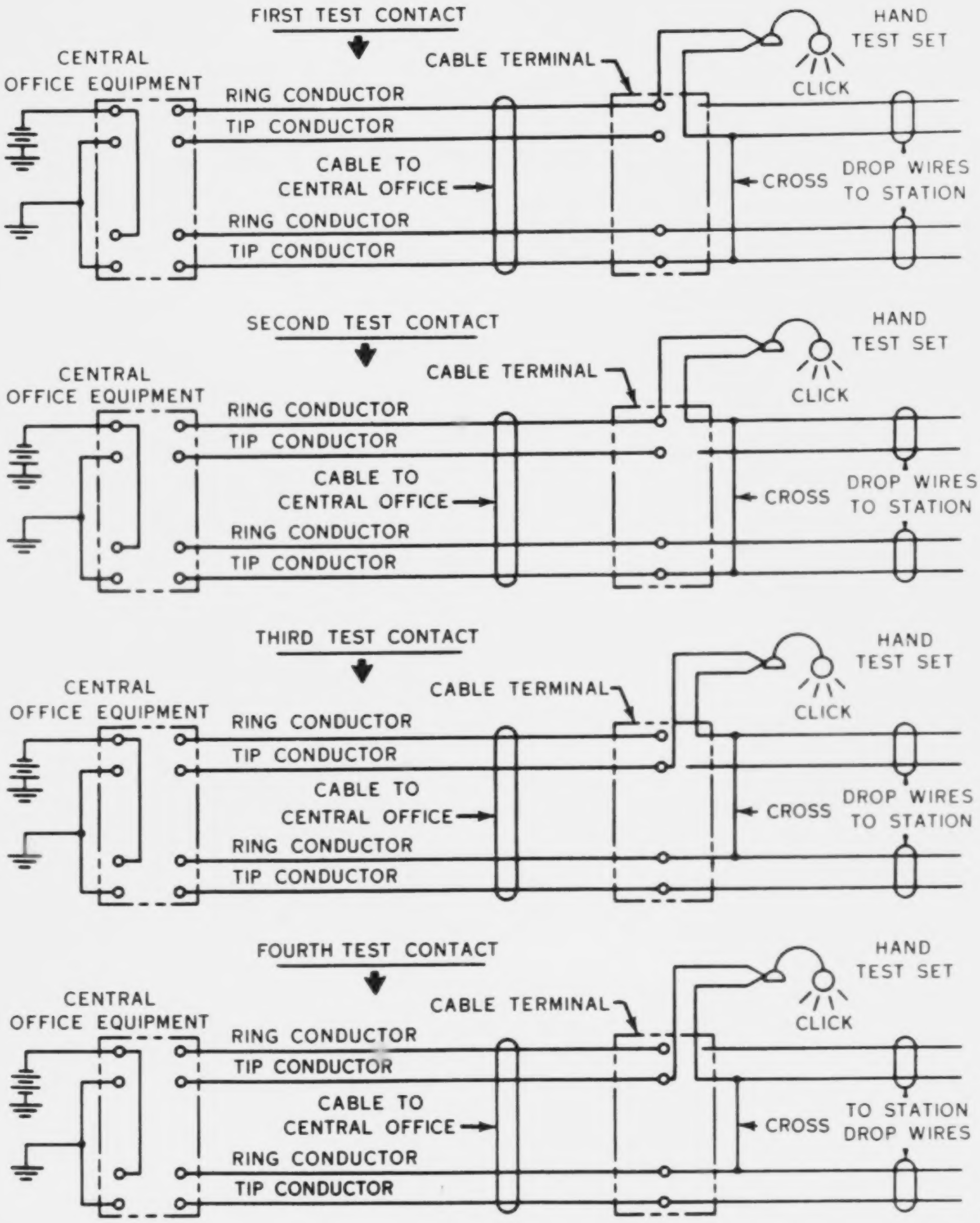
FIRST TEST CONTACT
CENTRAL OFFICE EQUIPMENT
CABLE TERMINAL
HAND TEST SET
CLICK
RING CONDUCTOR
TIP CONDUCTOR
CABLE TO CENTRAL OFFICE
CROSS
DROP WIRES TO STATION
RING CONDUCTOR
TIP CONDUCTOR
SECOND TEST CONTACT
CENTRAL OFFICE EQUIPMENT
CABLE TERMINAL
HAND TEST SET
CLICK
RING CONDUCTOR
TIP CONDUCTOR
CABLE TO CENTRAL OFFICE
CROSS
DROP WIRES TO STATION
RING CONDUCTOR
TIP CONDUCTOR
THIRD TEST CONTACT
CENTRAL OFFICE EQUIPMENT
CABLE TERMINAL
HAND TEST SET
CLICK
RING CONDUCTOR
TIP CONDUCTOR
CABLE TO CENTRAL OFFICE
CROSS
DROP WIRES TO STATION
RING CONDUCTOR
TIP CONDUCTOR
FOURTH TEST CONTACT
CENTRAL OFFICE EQUIPMENT
CABLE TERMINAL
HAND TEST SET
CLICK
RING CONDUCTOR
TIP CONDUCTOR
CABLE TO CENTRAL OFFICE
CROSS
TO STATION DROP WIRES
RING CONDUCTOR
TIP CONDUCTOR

Figure 5–16. Schematic diagram of tests for isolating a cross.

6. State the procedure to use with the free test lead when testing for a grounded telephone pair.

7. When working as a teammate with the test desk operator, what is your primary task?

8. Describe a good procedure for determining subset and line intermittent type faults.

9. What condition should you look for if you suspect high resistance?

10. When using a hand test set in testing for a telephone line crossconnection, specify the connections to make with its two leads.

5-5. Trouble Elimination

The type of repair that is required for a particular substation trouble must, of course, be determined by the type of trouble and its location. In each case, the repair required is a repetition of the installation steps. Probably a connection is not clean or maybe a wire is damaged.

473. Identify typical telephone system repairs to be made by installer-specialists.

Telephone System Repairs. Repairing wire breaks or other damage depends upon the location of the damage. After you have isolated the fault to a particular section of the installation, you must then find its specific location. In most cases, it is possible to pinpoint the exact location of the fault by a careful inspection of the wire involved. In cases of swinging or high-resistance faults, make sure that all connections are tight and clean. Cut out faults located in sections of drop, block, or station wiring and splice in a new section, provided that the installation is relatively new. Replace a line that has deteriorated extensively or where further trouble appears imminent. If you cannot remove the cause, such as trees or a building obstacle, relocate the line adjacent to that point.

If you've traced the trouble to the protector, check the fuses and inspect the carbon blocks. If the carbon blocks are damp, wipe them dry; in some cases, you may have to relocate the protector to avoid these conditions. If the carbon blocks are dirty or pitted, decided whether it is better to clean or to replace them. If you decide is to clean them, be careful that you do not increase the airgap between the blocks.

Connecting blocks seldom cause service interruptions unless they are struck by an object which dents the cover or breaks the base. You can easily correct these troubles by replacing the damaged parts. If the inside wiring is grounded or broken, you may repair it with a splice; however, if it has deteriorated, replace it.

When you find the trouble is in the cable or line, you must then report the situation to the central office. In this case, the wire chief will usually assign another pair (if available) for use with the station on which you are working.

Exercises (473):

1. What repair is most often used to overcome a high resistance fault indication?

2. Identify two probable methods for overcoming a drop wiring fault that is routinely evident when the wind blows or when it rains.

3. Describe probable maintenance tasks for carbon blocks in a protector.

4. State a typical repair task for an inside wire.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

400 – 1. Central office.
400 – 2. Line area.
400 – 3. Substation area.
400 – 4. Substation area, telephone, and terminal-can.

401 – 1. (1) d; L.
(2) g; F.
(3) e; L.
(4) h; F.
(5) j; F.
(6) b; F.
(7) i; L.
(8) a; L.
(9) c; F.
(10) f; F.

402 – 1. (1) c.
(2) d.
(3) b.
(4) a.
(5) a.
(6) b.
(7) c.
(8) d.

403 – 1. T.
403 – 2. F.
403 – 3. T.
403 – 4. F.
403 – 5. T.
403 – 6. F.
403 – 7. T.
403 – 8. T.

404 – 1. Bench stock is a supply of spare parts that can't be locally repaired.
404 – 2. Local bench-stock records, bench-stock bins, and master file.
404 – 3. Justification for need of the new stock.

405 – 1. Inspect the area where the installing is to be done, talk with the user(s), study installation specifications, and order required materiel and equipment.
405 – 2. AFR 66–1, supply publications, and the applicable equipment specifications.
405 – 3. Wire, anchor devices, hardware, and building attachments.

406 – 1. (1) d.
(2) g.
(3) a.
(4) e.
(5) h.
(6) j.
(7) i.
(8) c.
(9) f.
(10) b.

407 – 1. Some factors to consider during inside wiring planning include: Does the building have an existing system? Is the wire to be in a hot or humid location? What is the size of the building? what number of stations are required? What features are requested?
407 – 2. Wire, connecting blocks, building attachments, ringer box, and telephones.

408 – 1. T.
408 – 2. T.
408 – 3. D.
408 – 4. T.
408 – 5. T and D.
408 – 6. T.
408 – 7. D.

409 – 1. 3.
409 – 2. 2.
409 – 3. 6.
409 – 4. 1.
409 – 5. 4.
409 – 6. 5.

410 – 1. Telephone wire clearance in this case is the required vertical distance between ground and the lowest point in the wire span.
410 – 2. Clearance between service wires is the required separation—horizontally and vertically—between wires and devices.

411 – 1. Wire clearance safety.
411 – 2. Installation appearance.
411 – 3. To avoid the tree by running the drop wire from the pole to the building adjacent to the station.
411 – 4. The drop wire wasn't taken directly from the pole but came down from a span clamp located at a distance from the pole.

412 – 1. Abnormal surges in voltage.
412 – 2. Indoor, outdoor, fuse, fuseless, and high voltage.
412 – 3. 1 foot.
412 – 4. 5 feet.
412 – 5. Install it where it is not subject to damage and where it can be inspected and corrected easily.

413 – 1. Test and telephone plant equipment.
413 – 2. A distribution-type pole mounted terminal has only one grouping of terminals, while a cross-connect pole mounted have two groupings.
413 – 3. Lineman's body belt and safety strap and lineman's climbers.

414 – 1. To select, procure, and learn the proper use of tools used by your team.
414 – 2. Diagonal pliers.
414 – 3. A hacksaw having a blade with 32 teeth per inch.
414 – 4. A drawknife.
414 – 5. Lineman's wrench.
414 – 6. Wire wrap tool.

415 – 1. Establishing priorities.
415 – 2. Time standard guideline.
415 – 3. Making immediate decisions and giving verbal instructions.
415 – 4. Determining worker assignments and giving safety briefings.

CHAPTER 2

416 – 1. To repair telephone drop wires and to connect ground rods to telephone drop wires.
416 – 2. Single—and double-bore types.
416 – 3. The .045–.040 diameter, 1⅞ inch-long sleeve.
416 – 4. The .064 × .045–.040 diameter, 1⅞ inch long sleeve.

417 – 1. (1) f.
(2) a and e.
(3) d.

418 – 1. Remove the jacket and separate the conductors so that you have freedom of movement while performing the remaining procedures.
418 – 2. Cut the conductors to be spliced (one short and one long) and remove the insulation at the end of each, leaving only bare wire at the end of the conductor.
418 – 3. The bared wires are inserted into the sleeves as far as they can go and the sleeves are compressed onto the conductors.
418 – 4. Six.
418 – 5. Tape over the completed splice.
418 – 6. Wires of the same color and for the same circuit must mate and the mating conductors must be staggered to eliminate the possibility of a circuit short.

419 - 1. (1) 4.
(2) 6.
(3) 3.
(4) 1.
(5) 7.
(6) 2.
(7) 5.

420 - 1. (1) d.
(2) c.
(3) e.
(4) f.
(5) a.
(6) g.
(7) h.
(8) b.

421 - 1. The solder must form a concave fillet which is smooth and continuous from the wire to the terminal.
421 - 2. The solder coating the wire must be adequate to cover the wire, yet light enough to allow its contour to be seen.

422 - 1. Tinning.
422 - 2. File the tip to remove pits and impurities, heat the iron, and apply a thin layer of rosin-core solder to the filed side of the heated tip.
422 - 3. Tinning.
422 - 4. It must be shiny and free of nicks or cuts.
422 - 5. Place the iron against the metal surface and the solder against the iron and termination junction point, and let the solder flow around the tinned conductor and termination.
422 - 6. Place the iron under the metals to be soldered and apply the solder to the top of the heated conductors until a thin coating covers the termination.
422 - 7. Allow no movement of the soldered connection until it has cooled down.

423 - 1. The D-rings rest just behind the raised area of your hip bones and the belt is tightened just enough to prevent it slipping below your hips.
423 - 2. Snapped on the right side D-ring with the hook keeper facing in opposite directions.
423 - 3. Tightened around the leg 1/2 inch below the small bone at the innerside of the knee cap.

424 - 1. Inspect each item.
424 - 2. Broken threads, thinness, cracks, cuts, and hardness or brittleness.
424 - 3. Broken or defective parts, rust, looseness, and excessive wear.
424 - 4. Clean it with saddle soap and preserve it with neat's-foot oil.
424 - 5. Measure it with a gaff gage.

425 - 1. Never wear climbers when you don't need them; never wear them on a ladder, or in deep snow.
425 - 2. Test the snaphook for free movement before climbing a pole, and never rely on the sound of the the keeper click when attaching the snaphook to the D-ring. Check to insure that the connection is properly made.
425 - 3. Do not place the safety strap within 1 foot of the pole top, insure that the strap doesn't become twisted during placement, and don't fasten it to the ladder you're using for the installation.
425 - 4. Inspect the pole for cracking, soft spots, leaning, and other climbing obstacles.
425 - 5. Bend the arms slightly; keep your hips farther from the pole than the rest of the body; thrust your legs inward and downward; your hands must never overlap around the pole, yet they must not reach only to the side of the pole; and your body weight should be entirely on the gaffs so that you will not be strained or uncomfortable.

CHAPTER 3

426 - 1. Drive ring, drive hook and drop wire clamp.
426 - 2. Poles, buildings and span clamps.
426 - 3. Suspension strand.
426 - 4. Guardarm hook.

427 - 1. L.
427 - 2. W.
427 - 3. W.
427 - 4. L and W.
427 - 5. L.
427 - 6. W.
427 - 7. L and W.
427 - 8. W.

428 - 1. (1) d.
(2) h.
(3) g.
(4) a.
(5) j.
(6) c.
(7) e.
(8) i.
(9) b.
(10) f.

429 - 1. (1) e.
(2) d.
(3) b.
(4) b and d.
(5) a and c.
(6) b and d.
(7) a.
(8) b and d.
(9) c.
(10) e.

430 - 1. One attachment should be placed at opposing sides of the corner and at the same horizontal level.
430 - 2. C-knobs.
430 - 3. About 8 inches.
430 - 4. Form a drip loop between the entrance hole and the last building attachment.
430 - 5. 9 feet.
430 - 6. 12 feet.
430 - 7. 5 feet.
430 - 8. Drop wire clamp.

431 - 1. At least 1 inch.
431 - 2. Attach drop wire to guardarm hooks or the guardarm.

432 - 1. Installing cable in conduit.
432 - 2. Burying it directly underground.
432 - 3. Lay the cable with equipment that opens the ground, inserts the cable and then buries it, or place it in a trench dug by machine or by hand.
432 - 4. Handle a reel with care while taking it to the installation area and cover it with a tarpaulin to limit its exposure to the weather.
432 - 5. Cuts, nicks, and breaks.
432 - 6. 18 to 20 inches.
432 - 7. Metallic pipe, bakelite or porcelain duct, and wood conduit.
432 - 8. 18 inches.
432 - 9. The cable must be long enough to make a proper termination and it must be protected from mechanical and electrical damage.

433 - 1. Large enough to accommodate the wire(s) to pass through it, yet never greater than half the width of the material through which the hole is to penetrate.
433 - 2. It must slope up (from outside up toward the inside).
433 - 3. Drill in the mortared seam.
433 - 4. Neat appearance of the completed work.
433 - 5. Where service entrance conduit is being used and in brick or masonry type buildings.

434 - 1. (1) d.
(2) c.
(3) a.
(4) b and h.
(5) b.
(6) g and f.
(7) a.
(8) f and g.

435 – 1. The cold water pipe.
435 – 2. Ground rod.
435 – 3. At least 12 inches.
435 t– 4. Nos. 6, 12, and 14 AWG wire.
434 – 5. Either No. 12 or No. 6 wire.
435 – 6. Close to the wall in the building basement.
435 – 7. Do not bend it to an angle less than 90°.
435 – 8. Short sections are permitted only as straps.
435 – 9. Instrument, inside, and ground wires must be kept separated and the ground wire to one ground rod must be separated by 6 feet from any other ground rod.

436 – 1. (1) a, b, c, and d.
  (2) d.
  (3) b.
  (4) a, b, c, and d.
  (5) a.
  (6) a, b, c, and d.
  (7) c.

437 – 1. 10 feet.
437 – 2. 6 inches.
437 – 3. The ground wire is connected to the conduit at an installed fitting (see fig. 3-39).

438 – 1. Location.
438 – 2. Service life.
438 – 3. Install the wire along or within a molding.
438 – 4. Always install it so that it won't be getting damaged.
438 – 5. At least 1 foot.
438 – 6. Within 3 inches.

439 – 1. Drive and toggle bridle rings.
439 – 2. Cable clamps and wire staples.
439 – 3. Never fasten wires directly to pipes or pipe supports.

440 – 1. R and S.
440 – 2. R and S.
440 – 3. R, P, and S.
440 – 4. R, P, & S.
440 – 5. R and S.
440 – 6. S.

441 – 1. (1) b.
  (2) c.
  (3) b.
  (4) d.
  (5) b.
  (6) c.
  (7) b.
  (8) e.
  (9) a.
  (10) a and d.
  (11) c.
  (12) b.
  (13) a, d, e, and f.
  (14) b.
  (15) a, d, e, and f.
  (16) e.
  (17) f.

442 – 1. Rubber and metal.
442 – 2. Metal.
442 – 3. The 5-foot length largest size duct.
442 – 4. Remove the preformed twistout.
442 – 5. Mate a tongue with the associated fitting and anchor the duct to the floor with screws.

443 – 1. A connecting block.
443 – 2. A distribution terminal.
443 – 3. It should be accessible to servicing personnel, and it should be an adequate distance from power lines and receptacles to be safe.
443 – 4. Be sure the tip conductors are mated and, likewise, the ring conductors must mate.
443 – 5. Wind the station wire around the central section before attaching the conductor under the terminal.
443 – 6. Run each pair through the fanning strip parallel to the terminals it accesses and provide enough slack in each wire pair so that the wire could be terminated at any terminal on the block.

444 – 1. An explosion-proof telephone.
444 – 2. Extension ringer and buzzer.
444 – 3. Extension telephone with loud ringing bell.
444 – 4. Transfer key.
444 – 5. Condenser.
444 – 6. Screw terminals.
444 – 7. Attach a wooden backboard to the panel.
444 – 8. It must be neat and, if possible, should be concealed.
444 – 9. Place rubber grommets in the hole or wrap the wires with tape.
444 – 10. The two windings are connected so that the current flow in one winding is in a different direction than that for the second winding.
444 – 11. Use of a plug-in cord on the telephone and jack-type outlets at the connecting blocks permits flexibility in a telephone's use.
444 – 12. Rigid conduit.

CHAPTER 4

445 – 1. Provide proper drop wire sag and make good connections at the pole terminals.
445 – 2. Figure 4-1 shows that the first connection is made at the building and figures 4-2 and 4-3 show that the wire is raised to the pole top last.
445 – 3. A handline.
445 – 4. Tie them together with a bowline knot.
445 – 5. Clove hitch.
445 – 6. Leave adequate slack to provide wire for the run to the terminal and for making the termination.
445 – 7. Clearance between wire and structures and probable damage from swinging wires.
445 – 8. 7 feet.
445 – 9. 30 pounds.
445 – 10. Four feet is required in all heavy load zone area states.
445 – 11. Two feet 2 inches.
446 – 1. (1) d.
  (2) f.
  (3) b.
  (4) h.
  (5) a.
  (6) b.
  (7) c.
  (8) f.
  (9) b.
  (10) e.
  (11) i.
  (12) g.

447 – 1. Bridle rings.
447 – 2. Five inches.
447 – 3. Run the wire through the side of the terminal opposite to where it will be attached and through three bridle rings installed below the terminal.
447 – 4. The installation must have the proper clearance and be neat.
447 – 5. Loosen the applicable nuts, insert wire under the screw and washer, and again tighten the nut and washer. Insure that there is no connection of the wire with an adjacent terminal.
447 – 6. Sleeve and cap-type binding post insulators.
447 – 7. Bridging terminal.

448 – 1. Binding post. Loosen the top nut, slip the wire under the lower washers and tighten the nut against the wire.
448 – 2. Between the first and second wire, 3/4 inch above the bottom of the crossarm.
448 – 3. Locate them where they are accessible and where they will not obstruct the climbing space.
448 – 4. Drive rings separated not more than 20 inches.
448 – 5. Bridging sleeve.
448 – 6. It is to be on the North side of the pole and below the lowest pole bracket.

449 – 1. Provide slack in the wire between the drop wire hook and the nearest drive ring.
449 – 2. Two or three.
449 – 3. Bare each wire by removing the wire jacket and conductor insulation.
449 – 4. Install rubber grommets or wrap friction tape around the wire.
449 – 5. Bridle wire.
449 – 6. The drop wire conductors are to be placed under the binding post lower washers and the bridle wire conductors are to be under the upper washers.
449 – 7. Bridle wire jumper conductor and open line conductor.
449 – 8. Having looped the bridle wire around the connector shaft and lifted the connector over the open line, tighten the nut until both wires make solid contact with the intervening washer.

450 – 1. (1) a and c.
(2) a and c.
(3) a and c.
(4) a, c, and d.
(5) a and c.
(6) a and b.

451 – 1. (1) e.
(2) d and g.
(3) b.
(4) f.
(5) e, f, and i.
(6) c and d, e & f.
(7) e, f, and h.
(8) a.

452 – 1. (1) d.
(2) g.
(3) e.
(4) a.
(5) c.
(6) f.
(7) b.

453 – 1. Zero amperes and infinite resistance
453 – 2. Short-circuit and continuity.
453 – 3. Voltage.

454 – 1. (1) a and b.
(2) a, b, and c.
(3) b.
(4) a and b.
(5) c.
(6) a, b, and c.
(7) a and c.
(8) a, b, and c.

455 – 1. (1) a.
(2) a and b.
(3) a.
(4) a and b.
(5) b.

456 – 1. Connect the telephone test set to the assigned pair and attempt to converse with a person at the central office.
456 – 2. To identify the conductors as tip and ring.
456 – 3. Tip and ring of the line pair.
456 – 4. The ring conductor.
456 – 5. A test of the ring conductor should result in a loud click whereas the test of the tip conductor results in no sound or in a very reduced click.
456 – 6. Sidetone indicates that the line circuit to the central office is good.
456 – 7. Ringing circuit test.
456 – 8. Transmission test and reception test.
456 – 9. Noise test.
456 – 10. Dial speed test.
456 – 11. A fault line is probable.
456 – 12. The telephone bell won't operate.
456 – 13. The telephone cord or cord connections are faulty.
456 – 14. Confirm the cable pair, list the materiel used, and sign the completed form.

CHAPTER 5

457 – 1. Inspection and preventive repair.
457 – 2. Look for proper attachment, broken insulation and conductors, discolored protective blocks and clearance from neighboring devices.
457 – 3. Look for a good attachment to ground and for a normal appearance for the carbon blocks and fuse (no discoloration nor displacement of the devices).

458 – 1. To keep equipment operating efficiently and to reduce or eliminate system downtime.
458 – 2. The program must be emphasized by the supervisory personnel, it must be skill-oriented, it must show specialists the symptoms of corrosion, and it must provide instruction about approved methods for reporting, preventing, and treating corrosion.
458 – 3. Equipment will last longer, the cost of maintenance will be reduced, and there should be fewer replacements of units (reduced cost for equipment).
459 – 1. Electrochemical corrosion.
459 – 2. Chemical corrosion.
459 – 3. Metal blistering, cracking and metal fatigue.

460 – 1. Various environmental conditions, and poor housekeeping and maintenance.
460 – 2. High temperature, high humidity, condensation.
460 – 3. Dust and moisture spillage.
460 – 4. Powder, rust, blisters, and pitting.

461 – 1. Planning is most important.
461 – 2. Moisture is the primary cause for corrosion.
461 – 3. Keep protective covers in place.
461 – 4. Use a pumice paste mix, a light rubbing action, and a short cloth to remove corrosion debris.
461 – 5. Paint and grease.

462 – 1. (1) b.
(2) b.
(3) a and b.
(4) a.
(5) a.
(6) a.
(7) b.
(8) a and b.
(9) a.
(10) a and b.
(11) a and b.
(12) b.
(13) a.
(14) a.
(15) a.
(16) a.
(17) a.
(18) a.
(19) a.
(20) a.

463 – 1. Operational check.
463 – 2. Transmission and signaling.
463 – 3. Inspection.
463 – 4. Continuity test.
463 – 5. Lift the handset, listen for dial tone and for sidetone, dial, talk, and move the telephone cords.
463 – 6. Dial clicks, bell tapping, sizzling noises.

464 – 1. Continuity, voltage, and resistance tests.
464 – 2. No dial tone and "cannot hear."
464 – 3. Short circuit and open line.

465 – 1. (1) g.
(2) e and h.
(3) j.
(4) k and l.
(5) a.
(6) a, b, f, g, and i.
(7) e, g, and h.
(8) b, c, g, j, k, and l.

(9) a, c, and d.
(10) e.
(11) d.
(12) b, c, e, f, g, i, j, k, and l.
(13) e, g, and h.
(14) f and i.
(15) b, c and g.
(16) g.
(17) h.
(18) b, c, e, f, g, h, i, j, k, and l.

466 t- 1. Continuity and low resistance.
466 – 2. A continuity reading because the pointer will not provide an accurate resistance reading for that setting during this test.
466 – 3. This is not considered to be defective because the resistance values for the 101A induction coil windings are considered to be satisfactory when they don't vary more than 10 percent from the amount specified.
466 – 4. 135 ohms.
466 – 5. An ohmmeter; look for resistance in the winding and a momentary deflection at the capacitor following test lead reversal.
466 – 6. Ohmmeter; continuity.
467 – 1. The dial pulsing contact.
467 – 2. Test points D and E.
467 – 3. In a circuit such as shown in figure 5-3, if the test from point A to C is satisfactory but no sound comes through the test receiver when testing between points A and D, it indicates that the circuit is open between points C and D and the trouble is in either the lead or the hookswitch contacts between points C and D.
467 – 4. If you don't hear a click when testing between points A and B in a circuit such as shown in figure 5-4, it indicates that the circuit is open between these points and that the trouble is in either the RED or WHITE leads or in the receiver units.
467 – 5. If you don't hear a click when the leads of the test set are placed directly across the terminals of the headset receiver, it indicates that the receiver unit is faulty.

468 – 1. Replace the assembly.
468 – 2. Replace the telephone at the station and the hookswitch assembly at the workcenter.
468 – 3. The ringer coil, coil core, and gongs are the only parts of the modern ringer that may be replaced. However, since the coil and core should not be removed unless you have facilities for recharging the permanent magnet, it is the normal procedure to replace the assembly whenever the ringer is found to be defective.
468 – 4. Replace the cord assembly.

469 – 1. Substation area.
469 – 2. Line area.
469 – 3. Central office area.
469 – 4. Opens, shorts, grounds, and crosses.
469 – 5. Transmission test.
469 – 6. Varley loop test.

470 – 1. (1) a, c, d, e, and h.
(2) c.
(3) a, b.
(4) a, b, d, e, and g.
(5) a, d, e, f, g, and h.
(6) b and f.
(7) e and f.
(8) c.
(9) g.
(10) h.
(11) a, b, c, d, and e.
(12) a, c, d, e, f, and g.
(13) a, b, d, e, and g.
(14) a and c.

471 – 1. Telephone, cable, pair, and pole number.
471 – 2. Building, floor, room and set location.
471 – 3. Sidetone evidence, sound volume, noise (transmission quality).
471 – 4. Priority of the service (a hospital, a defense emergency line, or a routine service line, etc).

472 – 1. Use a step-by-step isolation procedure.
472 – 2. At the applicable pole terminals.
472 – 3. A click or dial tone.
472 – 4. Either click or no dial tone.
472 – 5. Open the line loop.
472 – 6. Alternately touch both sides of the line.
472 – 7. To open the line at specified points.
472 – 8. Shake the wires briefly and gently.
472 – 9. Corrosion.
472 – 10. Attach a lead first to TIP and then second to RING at the terminal. Then, alternately touch the second lead to the suspect line section's TIP and RING conductors.

473 – 1. Clean the junction (termination) point and tighten the device(s) which join the wires or wire and terminal.
473 – 2. Replace the deteriorated wire of that line or relocate the line so that it does not lay close to the troublemaking object.
473 – 3. Wipe the carbon blocks dry, sand the block faces smooth of build-ups and pits, or preferably replace the blocks.
473 – 4. Splice damaged wires using specified procedures.

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STOP - 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
36254 03 22
SUBSTATION INSTALLATION

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet .
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

Note to Student: Consider all choices carefully and select the best answer to each question.

1. (400) The telephone system consists of each of the following except for

   a. central office area.
   b. line area.
   c. substation area.
   d. central receiving office.

2. (401) The wire which extends from the can on the terminal pole to the bracket on the building is

   a. a 26 pair, solid strand, neoprene jacketed wire.
   b. a 26 pair, silver stranded, rubber jacketed wire.
   c. referred to as the running cable.
   d. called the drop wire run.

3. (401) The substation area protector shields the telephone system from high

   a. voltages caused by lightning strikes.
   b. voltages caused by power capacitor surges.
   c. current produced by ground wire shunts.
   d. current produced when power fuses open.

4. (401) The connecting block at a substation is used for connecting the

   a. telephone wiring to the telephone terminals.
   b. drop run wiring to the protector.
   c. drop run wiring to the cable pair.
   d. inside wiring to the telephone cord.

5. (402) When planning a job, which of the following is a manning consideration?

   a. Tool design.
   b. Equipment cost.
   c. Equipment complexity.
   d. Type portector available.

6. (403) The inventory of newly purchased telephone equipment should include a study of

   a. the consumption data.
   b. each item's justification.
   c. its spare parts list.
   d. the bench stock record.

7. (404) Bench stock requirements should be analyzed for accuracy at least every

a. day.
b. week.
c. quarter.
d. year.

8. Arranging with materiel control for proper telephone system equipment in

a. evaluating.
b. directing.
c. planning.
d. delaying.

9. (406) Fused protectors are generally used in connection with

a. a steel (0.109 inch diameter) wire.
b. an aerial drop and block wire runs.
c. grounded sheath cable installations.
d. a 10 gage, rubber or plastic insulated ground wire.

10. (407) Which of the following type telephone wires should be installed where wiring extends outside of a building to the extension ringer?

a. A block wire.
b. A running cable.
c. A cross-connecting wire.
d. A plastic-jacketed station wire.

11. (408) What is specified in the CEIP?

a. Manpower and materiel only.
b. Financing authority and manpower only.
c. Hardware, construction, money, and manpower.
c. Workcenter identification, manpower needed and available, and C-E officer.

12. (409) When planning for an installation, consider unusual activities that would affect the installation and the

a. duct design specifications.
b. conduit construction specifications.
c. desires of the customer.
d. experience and qualifications of the customer.

13. (410) The vertical distance between the lowest point in a wire span and the ground level is

a. to be not less than 15 feet 3 inches.
b. to be not more than 20 feet 3 inches.
c. the clearance specification.
d. prescribed in AFR 205-1.

14. (411) The appearance of the drop wire and the requirement for saving materiel are

a. installed according to standard practices.
b. always planned by the communications officer.
c. now limited to common line system.
d. based upon major command specifications.

15. (412) When planning protector requirements for a telephone installation, you should remember that the protector is not used on installations connected to

a. circuits parallel to 2000 volt power lines.
b. an underground shielded cable.
c. open wire lines.
d. an aerial cable.

16. (412) When a station protector is mounted outside it should

a. be within 5 feet of the ground.
b. be within 6 to 8 feet from the ground.
c. be separated from power wires by not more than 1 foot.
d. not be close to the building entrance hole.

17. (413) Installation equipment which a team leader may procure for a telephone system includes the

a. pole and fused indoor mounted terminals.
b. pole and pedestal mounted terminals.
c. pedestal and crossed fused terminals.
d. fused, weatherproof cross-connected terminals.

18. (414) Two important subjects in your training are

a. selecting and properly using tools.
b. modifying and recording specifications.
c. inspecting and repairing test equipment.
d. removing and replacing MDF terminal blocks.

19. (414) Which of the following hacksaw blades would you use to saw heavy materiels?

a. A blade having 16 teeth per inch.
b. A blade having 14 teeth per inch.
c. A blade having 20 teeth per inch.
d. A blade having 32 teeth per inch.

20. (414) The tool best used for tightening nuts onto pole mounted terminal binding posts is the

a. adjustable jaw wrench.
b. lineman's wrench.
c. long-nose pliers.
d. diagonal pliers.

21. (415) A team leader controls a project by assigning workers, stressing work safety, planning instructions,

   a. appointing an alternate leader, allowing deviations, and using aggressive commands.
   b. analyzing deviations to overcome delays and by limiting use of time standards.
   c. assigning priorities, developing timetables, and reviewing plans.
   d. accepting temporary unsafe procedures while developing bypass procedures.

22. (416) In wiring which of the following splices is preferred?

   a. The twisted-conductor splice.
   b. The compressed sleeve splice.
   c. The single drop twisted splice.
   d. The double drop compressed splice.

23. (417) Typical sleeve preparation tools include a

   a. longnose pliers, an adjustable jaw wrench, and a draw knife.
   b. wire stripper, a sleeve compression tool, and a diagonal pliers.
   c. lineman's pliers and a draw knife.
   d. a diagonal pliers and a lineman's wrench.

24. (416) Using Table 2-1 of the text, the single-bore diameter compression sleeve used to splice parallel drop wire is size

   a. .032-.025 and 1 inch in length.
   b. .032-.025 and 1 7/8 inch in length.
   c. .045-.040 and 1 7/8 inch in lenth.
   d. .064 and 1 7/8 inch in length.

25. (418) When using compression sleeves to splice the conductors of a parallel drop wire, the sleeves must be

   a. staggered to strengthen the splice.
   b. staggered to reduce foreign battery induction.
   c. fitted to the conductor with the insulation intact.
   d. fitted to the conductor with the insulation removed.

26. (419) What length of bare wire should be used for each conductor when preparing to make [illegible] Western Union splice?

   a. 2 inches.
   b. 4 inches.
   c. 6 inches.
   d. 8 inches.

27. (420) When a drop wire splice is properly soldered, corrosion is held to a minimum because

a. air is removed by the heated flux.
b. air is restricted by the solder.
c. moisture is sealed within the splice.
d. the splice surface absorbs the oxygen of external air.

28. (420) The soldering tip temperature is more constant when

a. an electric iron is used.
b. a soldering copper is used.
c. an electric iron is charged with a chemical cartridge every 7 minutes.
d. a soldering copper is charged with a chemical cartridge every 7 minutes.

29. (421) Which of the following conditions should be noted of a good solder connection?

a. Small pits, a concave fillet, and a high resistance.
b. Wire touching the terminal, contour of wire visible and forming a concave fillet.
c. Small pits, a convex fillet at the terminal, and a high resistance.
d. A rough, convex fillet between terminal, and the wire, and a visible wire on terminal.

30. (422) How should a properly tinned soldering iron tip be described?

a. As having a rough, tarnished appearance.
b. As having a pitted, silver grey appearance.
c. As being smooth with a thin coat of solder on its working surface.
d. As having a rough copper bronze appearance.

31. (423) The measurement of a lineman's body belt is determined by

a. measuring the lineman's hips and adding 4 inches.
b. measuring the lineman's waist and adding 4 inches.
c. the distance between the buckle and the D-rings.
d. the distance between the D-rings.

32. (424) To properly preserve the body belt, the specialist should

a. cleean it with a detergent soap and oil it with mineral oil.
b. clean it with a neutral soap and oil it with neat's foot oil.
c. oil it with mineral oil and hang it near a heating source to dry.
d. coat it with neat's foot oil and hang it near a heating source to dry.

33. (425) Which of the following statements is a safety rule for using climbers?

a. When working on a ladder, fasten the safety belt to the ladder.
b. Keep the keeper on the snaphook close to your body when the snaphook is fastened to the D ring.
c. When working on a pole be sure to twist the strap.
d. Do not wear climbers when working on the ground.

34. (425) While climbing, your legs must

a. be relaxed so your weight can be distributed between your arms and legs.
b. break wood from the pole as the gaff is withdrawn.
c. be straight while supporting the body weight.
d. bend while supporting the body weight.

35. (425) It is good practice for the installer, when

a. a descending the pole, to keep the gaff 10 inches above the supporting foot.
b. beginning to climb, to jab the gaff in the pole 20 inches above the ground.
c. climbing the pole, to look at his feet frequently to be sure not to hit a knot or other obstruction.
d. descending a pole, to use the same upward and outward motion in freeing the gaff as used when climbing.

36. (426) The wire from the terminal pole to the first building attachment is

a. always a submarine type, 6-pair cable.
b. the terminal run.
c. the drop wire run.
d. the span run.

37. (426) Figure 3-1 of the text shows which of the following devices used as pole attachments?

a. Span and drop wire clamps.
b. Drive hooks and rings.
c. Drive and screw anchors.
d. C, S, and T knobs.

38. (427) When using a ladder to attach a drop wire to a cable strand, you should

a. attach your safety belt to a ladder rung.
b. hold the handline in one hand while climbing the ladder.
c. place the ladder on the same side of the cable strand as the drop wire is on.
d. place the ladder on the side of the cable strand opposite to where the drop wire is located?

39. (428) When installing a drop wire run from a non-ground cable, the installer should

a. toggle bolts on frame buildings.
b. short screw eyes on masonry constructed buildings.
c. angle screws with insulator supports on frame buildings.
d. a C-knob no closer than 12 inches of a drop wire hookd on masonry constructed buildings.

40. (429) If an insulating tube is required while installing a new building run, the installer should

a. use a solid-type tube, if available.
b. use a split-type tube, if available.
c. secure the tube in place with lashing wire.
d. extend the tube 2 inches beyond the ends of the entrance hole.

41. (429) If a rain spout is 2 inches in diameter is to be crossed, how long should the insulating tube be?

a. 2 inches only.
b. 4 inches only.
c. 6 inches.
d. 12 inches.

42. (430) A drip loop for a building run should be placed

a. at each building attachment.
b. at each end of a horizontal run.
c. between intermediate attachments.
d. outside of each building entrance.

43. (431) For a telephone installation, the installer avoids

a. a strain on the drop wire clamp.
b. a strain on the drop wire.
c. leaving slack on the ring wiring.
d. staggering the drive hooks on a pole.

44. (431) What is the required separation distance between the drive hook face and the pole face on which it is installed?

a. 1/2 inch.
b. 1 inch.
c. 2 inches.
d. 4 inches.

45. (432) Where a buried distribution wire is to cross a creek, protect the wire by

a. running it under the stream.
b. placing it in a galvanized pipe.
c. placing it in a single-pair rubber raceway.
d. treating it with a waterproof conduit solution.

46. (433) The entrance hole for a drop wire should be drilled in a position to provide for

a. a short inside wire run.
b. the proper location of the subset.
c. the shortest possible outside building run.
d. the proper location of the connecting block.

47. (433) When drilling an entrance hole in brick or masonry, the hole should be drilled

a. to permit the insulating tube to extend 1-1/4 inches beyond the wall.
b. large enough to accommodate the proposed and anticipated wiring.
c. large enough to permit the spreading of the insulating tube.
d. so that the hole slopes toward the inside.

48. (434) Inproperly mounted protectors allow carbon dust to create

a. an undesirable ground.
b. a high pitched tone.
c. a low pitched sound.
d. crossed pairs.

49. (434) The ground and station wire terminals for an inside protector are

a. 1 foot on either side of the protector assembly.
b. 5 feet above the protector assembly.
c. at the top of the protector assembly.
d. at the bottom of the assembly.

50. (435) A telephone installer should ground a station protector by connecting it with

a. a BUSS bar to the instrument ringing circuit.
b. a BUSS bar to the building circuit breaker.
c. a pipe coming from the water heater.
d. an incoming pipe from the base water system.

51. (436) Which of the listed requirements pertain to a telephone set?

a. Locate it in a dry place, separated from grounded metallic objects and electrical appliances.
b. Locate it in a temperature controlled location, and no more than 1 foot from any electrical appliance in the building.
c. Clean it with castile soap and lubricate the moving components with neat's foot oil.
d. Clean it with trichlorethene and lubricate the moving components with neat's foot oil.

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52. (437) The distance between the outside telephone equipment protector cabinet and the ground should be

a. 8 feet on frame buildings and 10 feet on brick buildings.
b. 8 feet on brick buildings and 10 feet on frame buildings.
c. 6 feet for all buildings.
d. 10 feet for all buildings.

53. (438) What listed building practice permits the concealment of telephone wiring?

a. The use of rubber molding.
b. The use of wood quarter rounds.
c. Inside wall air spaces.
d. Inside wall insulation batting.

54. (438) Which listed precaution applies to the insulation of inside telephone wiring?

a. It must not interfere with window operation nor span a stairway.
b. If joints must be spanned stay within 8 inches of the wall.
c. It must follow the baseboard line in a basement.
d. It must run beam-to-beam above work benches.

55. (439) The fastener most commonly used for attaching inside telephone wiring to a wall is the

a. staple.
b. wire tie.
c. hammer drive anchor.
d. toggle bridle ring.

56. (440) The use of conduit for inside wiring is least necessary where

a. mechanical or electrical damage is likely.
b. an exposed wire would be a hazard.
c. an exposed wire would be unsightly.
d. general office work is being accomplished.

57. (441) As used for inside wiring, the base raceway is

a. installed along the wall at the ceiling line.
b. installed along the wall at the floor level.
c. always made of wood.
d. always made of metal.

58. (442) The duct accessory to install when preparing to run wires up an interior wall is the

a. triple twistout.
b. single twistout.
c. elbow adapter.
d. rubber grommet.

59. (443) What are two factors to consider when preparing to install a connecting block?

a. Accessibility and safety.
b. The protector type and service life.
c. The terminal arrangement and fanning requirements.
d. The distance to central office and telephone system length.

60. (443) The station wire at connecting blocks should

a. have no slack.
b. be wound around the block.
c. be connected to the A and E terminals.
d. be connected to the E and F terminals.

61. (443) Fanning strips are installed for identification of

a. conduits.
b. raceways.
c. connecting blocks.
d. phone wires by station or room numbers.

62. (444) The slack required between the first-desk attachment and the floor outlet is

a. 3/8 inch.
b. 1 inch.
c. 1 foot.
d. 5 feet.

63. (444) In a telephone installation, a substitute protector for a rubber grommet at a telephone desk is

a. rubber tape.
b. a porcelain tube.
c. a wooden blackboard.
d. a carbon block.

64. (444) The common auxiliary telephone unit used to increase the area over which the telephone can be announced is the

a. switchboard amplifier.
b. network amplifier.
c. extension ringer.
d. magnet clapper.

65. (444) Explosion-proof telephones require

a. silver contacts.
b. a rigid conduit.
c. transfer keys.
d. gas.

66. (445) To raise a drop wire up to the drive hook or suspension strand you should

a. use a fishline, tie it to the drop line with a square knot.
b. use a handline, tie it to the drop line with a bowline knot.
c. push the drop line up with a pike pole.
d. pull it up with the use of a ladder.

67. (445) According to Table 4-1 of the text how much stringing sag is required in a 150 ft span of ordinary drop wire to obtain approximately 30 pounds of tension?

a. 1 foot.
b. 2 feet.
c. 4 feet.
d. 7 feet.

68. (446) The use of a polyethylene sheath and a conductor insulation permits the use of

a. an "underground service" terminal.
b. a "ready-access" distribution terminal.
c. service cable conductors.
d. video cable conductors.

69. (446) Between the drive hook and the pole terminal you are required to install

a. 15 terminal posts.
b. intermediate attachments.
c. two metal strips with hangers.
d. four twenty-four pair color coded fanning strips.

70. (446) A terminal visual area inspection includes

a. the terminal sleeve seal.
b. tree and line contact.
c. missing cable rings.
d. all of the above.

71. (446) Loose connections at the terminal can cause

a. cracks in wiped cable joints.
b. sleeve seal holes.
c. open circuits.
d. sidetones.

72. (447) Future telephone connections are assured when you

a. use bridle rings at crossarms.
b. make terminations with color coded wire.
c. leave extra wire at telephone terminals.
d. reverse tips and ring conductors alternately throughout the pole-mounted terminal.

73. (447) Binding post insulators are used at terminal assemblies to prevent

a. the interruption of police calls.
b. arcing at carbon blocks.
c. an accidental cross to another circuit.
d. bell tapping.

74. (448) What kind of wire should you use between the drop wire terminals and the open wires?

a. A tie wire.
b. An open wire.
c. A block wire.
d. A bridle wire.

75. (449) The maximum spacing between intermediate drive rings should be approximately

a. 20 inches.
b. 12 inches.
c. 3-1/2 inches.
d. 5/8 inches.

76. (449) Connecting an open wire line with a bridle wire is easily accomplished by installing a

a. connecting block.
b. bridging connector.
c. dead-end bracket.
d. "ready-access" terminal.

77. (450) Which of the listed sets permits you to arrange for the test desk operator to check the circuit?

a. The hand test set.
b. The Wheatstone bridge.
c. The multimeter.
d. The test lamp.

78. (451) To measure AC values, the PSM-6 multimeter is equipped with

a. both AC and DC metermovements.
b. a DC meter movement and a rectifier.
c. an AC meter movement and a converter.
d. a universal meter movement for both AC and DC.

79. (452) In the multimeter the AC DC 0 to 5 scale may be read as each of the following except as

a. 0 to 5.
b. 0 to 50.
c. 0 to 500.
d. 0 to 5000.

80. (453) You would most likely use the PSM-6 multimeter to

a. compare sine waves.
b. check for opens, proper voltage, and shorts.
c. monitor high frequency currents.
d. monitor output signals from amplifiers.

81. (453) An excellent device for checking for continuity in a communications circuit is

a. an ammeter.
b. an ohmmeter.
c. a voltmeter with an internal rectifier.
d. a voltmeter without an internal rectifier.

82. (454) When using the multimeter to measure voltages and currents, you should always connect the voltmeter in

a. series with the circuit to measure voltage.
b. parallel with the circuit to measure current.
c. parallel across the portion of the circuit in which voltage is to be measured and in series with the circuit when measuring current.
d. parallel to the circuit when measuring current and in series with the circuit when measuring voltage.

83. (454) When using the ohmmeter to measure the resistance of a circuit, you should always

a. connect the meter parallel to the voltage in the circuit.
b. connect the meter parallel to the current in the circuit.
c. disconnect the power source before you connect the ohmmeter.
d. disconnect the multimeter battery before you connect the test leads to the circuit.

84. (455) A receiver click set used for testing nonpowered circuits is normally constructed by connecting the telephone receiver

a. and battery in series with the two test leads.
b. in parallel with a battery and the two test leads.
c. in series with a battery, transmitter and the two test leads.
d. and battery in parallel with the transmitter and two test leads.

85. (456) Operational tests are performed on newly installed telephones primarily to

a. make a record of the installers identity and work quality.
b. insure that the new installation will function properly.
c. insure that a positive battery is on the ring conductor.
d. identify the central office.

86. (456) Having installed a dial telephone, the operational test includes a check for the

a. ringback tone, transmission, reception, protector operation, and the dial speed.
b. protector operation, sidetone, foreign voltage, ringing, and reception.
c. sidetone, antisidetone, voltage loss, and transmission.
d. dial speed, noise, reception, ringing, and transmission.

87. (456) An acceptable noise level is

a. 1-3 decibels.
b. the absence of noise.
c. indicated on central office instruments.
d. indicated by central office test equipment.

88. (457) When inspecting a station protector, insure that

a. it is grounded.
b. its tip conductor attachment is grounded.
c. its ring conductor attachment is grounded.
d. the connecting blocks and the fuse are open.

89. (458) Continuous operation of a telephone system is most probably the result of

a. a heavy load sagging in a medium load area.
b. an accurate design of corrosion susceptible materials.
c. an effective control of the station temperature.
d. a good corrosion control program.

90. (459) A grey or white powder on metal is

a. a symptom of fungus growth.
b. a symptom of chemical corrosion.
c. an indication of a cathode to anode electron flow.
d. an indication of too much stress during torquing.

91. (459) The most critical result of electrochemical corrosion is

a. fungus.
b. an unsightly appearance.
c. open conductors.
d. metal fatigue.

92. (460) Which of the listed symptoms are examples of severe corrosion?

a. Green film, white powder, and loose connections.
b. Shiny or blackened metal, rust, and flux residue.
c. Surface blisters, crossed circuit conductors, and easily moved controls.
d. Fine debris, localized abrasions, cracks, and deep grooves.

93. (461) Corrosion of the pole terminals is controlled or prevented by

a. coating with a noncorrosive paint.
b. coating with a noncorrective sealing compound.
c. installing components designed for outside use.
d. installing covers and housings that have good ventilation.

94. (462) What individual should identify the proper terminals of a circuit to be tested when isolating a fault to either a subset area or to a central office?

a. The deputy commander for maintenance.
b. The maintenance superintendent.
c. The workcenter supervisor.
d. The wire chief.

95. (463) When an inspection is completed, what two tests must be performed?

a. The voltage and current amplification tests.
b. The voltage and current elimination tests.
c. The transmission and signaling tests.
d. The open and short circuit tests.

96. (464) With the handset on its cradle and a ringing condition on the line and if there is no ringing of the telephone, this indicates that the trouble is in the

a. ringing circuit.
b. wiring between the terminal and protector.
c. wiring between the protector and the connecting block.
d. cord between the connecting block and the telephone subset.

97. (465) When inspecting a ringer assembly in a modern telephone, the finding of which of the following would necessitate a replacement of the ringer assembly?

a. A loose ringer gong.
b. A broken biasing spring.
c. An open ringing capacitor in the network.
d. A shorted ringing capacitor in the network.

98. (466) What is the resistance value specified for the primary winding of the 101A induction coil?

a. 5 ohms.
b. 19 ohms.
c. 22 ohms.
d. 75 ohms.

99. (467) Refer to figure 5-3 of the text. If sound comes through the test receiver satisfactorily while testing from points A to B, this would indicate that the RED and BLACK leads and the

a. subset transmitter are functioning properly.
b. test set transmitter are functioning properly.
c. subset receiver are functioning properly.
d. test set transmitter have continuity.

100. (468) A subscriber reports that she continuously gets wrong numbers when using the dial lines. From this report, what would most likely be your operational test?

a. Depress and release the hookswitch and determine the reliability of its operation.
b. Depress PICKUP key and look for a steady lamp.
c. Depress HOLD key and look for a flashing lamp.
d. Test the dial for speed.

101. (468) On the modern telephone, which of the following ringer parts can not be replaced?

a. The ringer coil.
b. The gongs.
c. The coil core.
d. The biasing spring.

102. (469) Common troubles for installers to repair are

a. line crosses, grounds, opens, and shorts.
b. open ground, insulation leakage, and swinging shorts.
c. slow dials, opens, low batteries, and shorts.
d. open straps, crossed lines, low pressure, and pitted contacts.

103. (469) What listed central office test equipment should be used to make a loop resistance test?

a. A current flow test set.
b. An auxiliary test cord.
c. A sounder cord.
d. A Wheatstone bridge.

104. (470) Which of the following installer actions could result in an open circuit?

a. Leaving an excessive shiner which touches a neighbor terminal.
b. Driving an inside wiring nail so that it penetrates the installed pair.
c. Allowing excess solder to flow over two terminals.
d. Making a loose connection at a terminal.

105. (470) Tip-ring and ring-to-ring are

a. two types of crosses that occur in telephone work.
b. two test desk test plugs.
c. names for central office indicator lamps.
d. selective ringing methods for testing drop wires.

106. (471) A typical telephone trouble report would include the following information: C1, pair 52, terminal 26, B1503, A2, and the

a. part number (101G).
b. telephone number (632-2359).
c. equipment type number (TA-500).
d. federal stock number (5805-503-1210).

107. (472) In telephone system troubleshooting do not cut any wires until you isolate the problem

a. to the line area.
b. to the subset area.
c. to the suspected connections.
d. between two adjacent points.

108. (472) What procedure is normally required to troubleshoot high resistance shorts?

a. Use the hand test set after shorting the end of the line.
b. Get the test desk operator to test the line and short the end of the line.
c. Get the test desk operator to test the line and open the line at specified points.
d. Have the test desk operator observe the central office trouble lamp while alternately opening and shorting the line at specified points.

109. (472) Which actions should isolate a telephone system intermittent open?

a. Use the hand test set and short the line.
b. Use the hand test set and open the line.
c. Inspect the terminal connections and shake the drop wire.
d. Inspect the protector fuses while shaking the inside wiring.

110. (473) What is the normal repair for faults located in sections of drop, block or station wiring?

a. Splice in a replacement section.
b. Bypass the damaged section with a new section.
c. Ask the wire chief for a spare pair and change the subset connections to it.
d. Test the pole terminals for potentials and change the subset connections to those having no click.

END OF EXERCISE

STUDENT REQUEST FOR ASSISTANCE

PRIVACY ACT STATEMENT

AUTHORITY: 10 USC 8012 and EO 9397. **PRINCIPAL PURPOSES:** To provide student assistance as requested by individual students. **ROUTINE USES:** This form is shipped with ECI course package. It is utilized by the student, as needed, to place an inquiry with ECI. **DISCLOSURE:** Voluntary. The information requested on this form is needed for expeditious handling of the student's need. Failure to provide all information would result in slower action or inability to provide assistance to the student.

SECTION I: CORRECTED OR LATEST ENROLLMENT DATA: *(Mail to: ECI, Gunter AFS AL 36118)*

1. THIS REQUEST CONCERNS COURSE (1 - 6)	2. TODAY'S DATE	3. ENROLLMENT DATE	4. AUTOVON NUMBER
5. SOCIAL SECURITY NUMBER (7 - 15) _ _ _ - _ _ - _ _ _ _	6. GRADE/RANK	7. NAME *(First initial, second initial, last name)* (17) (18) (19-32)	
8. ADDRESS *(OJT Enrollees -- Address of unit training office with zip code. All others -- current mailing address with zip code.)*	(33-53) (54-75)		
9. NAME OF BASE OR INSTALLATION IF NOT SHOWN ABOVE		10. TEST CONTROL OFFICE ZIP CODE/SHRED (33 - 39)	

SECTION II: REQUEST FOR MATERIALS, RECORDS, OR SERVICE

(Place an 'X' through number in box to left of service requested)

1	Request address change as indicated in Section I, Block 8.
2	Request Test Control Office change as indicated in Section I, Block 10.
3	Request name change/correction (Provide Old or Incorrect data)
4	Request Grade/Rank change/correction.
5	Correct SSAN. (List incorrect SSAN here) (Correct SSAN should be shown in Section I)
6	Extend course completion date. (Justify in REMARKS)
7	Request enrollment cancellation. (Justify in REMARKS)
8	Send VRE answer sheets for Vol(s): 1 2 3 4 5 6 7 8 9 Originals were: ☐ Not received ☐ Lost ☐ Misused
9	Send course materials. (Specify in REMARKS) ☐ Not received ☐ Lost ☐ Damaged
10	Course exam not yet received. Final VRE submitted for grading on ________ (date).
11	Results for VRE Vol(s) 1 2 3 4 5 6 7 8 9 not yet received. Answer sheet(s) submitted ________ (date).
12	Results for CE not yet received. Answer sheet submitted to ECI on ________ (date).
13	Previous inquiry (☐ ECI Fm 17, ☐ Ltr, ☐ Msg) sent to ECI on ________ (date).
14	Give instructional assistance as requested on reverse.
15	Other (Explain fully in REMARKS)

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OJT STUDENTS must have their OJT Administrator certify this request.	I certify that the information on this form is accurate and that this request cannot be answered at this station. *(Signature)*
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SECTION III: REQUEST FOR INSTRUCTOR ASSISTANCE

NOTE: Questions or comments relating to the accuracy or currency of subject matter should be forwarded directly to preparing agency. For an immediate response to these questions, call or write the course author directly, using the AUTOVON number or address in the preface of each volume. All other inquiries concerning the course should be forwarded to ECI.

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VRE Item No ________

Answer You Chose ______ (Letter)

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☐ Yes ☐ No

REFERENCE

(Textual reference for the answer I chose can be found as shown below)

In Volume No ________

On Page No ________

In ☐ left ☐ right column

Lines _____ Through _____

MY QUESTION IS:

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ADDITIONAL FORMS 17 available from trainers, OJT and Education Offices, and ECI. Course workbooks have a Form 17 printed on the last page.

36254 04 8102

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TELEPHONE EQUIPMENT INSTALLATION AND REPAIR SPECIALIST

(AFSC 36254)

Volume 4

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Preface

MOST communications systems are developed around the basic electrical principles; therefore, a person with a good knowledge of one communications system should soon be able to learn the features of a second. You should be able to give good equipment service if you can trace and analyze communications circuits. An efficient technician understands the theory and the normal function of each circuit in the system. That understanding permits intelligent analysis of equipment trouble.

Since the objective of communications maintenance is to insure accurate, rapid, and prolonged operation of Air Force equipment, delays must be held to a minimum. Consequently, when trouble comes, the service is to begin immediately and must be completed as soon as possible.

This volume describes the varied uses of telephone communicating systems. Also, it describes operating principles of exemplary equipment, thus giving procedures that apply to most systems. The example method is also used in describing installation, trouble analysis, and maintenance. Notation is made of the comparison between equipments, circuit principles, installation methods, and maintenance requirements described in other volumes.

This "home study" CDC, with the skill training you get during OJT, will broaden your knowledge and prepare you for complex tasks. You should realize that complex tasks are often a union of simple tasks; hence, by completing simple assignments you help solve a complex problem. When you need an answer to a question, ask one of the more experienced team members. A qualified technician is willing to help a trainee who is sincere in wanting to know—because the former understands that "knowing" is required of a capable member on the team.

At the end of this volume is a glossary, which defines many terms or words that are related to your job. Use it.

Included with this volume are seven schematic foldouts that are printed separately as 3 supplements.

Your completion of this volume aids you in learning the theory required for AFSC's 36254 and 36274. Your TOTAL training includes your further development through the JPG (Job Proficiency Guide) for the specific equipment and duties of your particular assignment, as well as management training for the 7 level.

Direct your questions or comments relating to the accuracy or currency of this volume to the course author, 3750 TCHTG/TTKMS, STOP 44, Sheppard AFB, TX 76311. If you need an immediate response, call AUTOVON 736-2088, between 0800 and 1630 (CST), Monday through Friday. *(NOTE: Do not use the suggestion program to submit changes or corrections for this course.)*

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to a Successful Course, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If this person can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This material is valued at 36 hours (12 points).

Material in this volume is technically accurate, adequate, and current as of August 1980.

Acknowledgement

THANKS ARE gratefully extended to the American Telephone and Telegraph Company and to Bell Telephone Laboratories for the copyrighted schematic diagrams shown in figures 2-1, 2-29 and 2-31 and foldouts 1 and 2, all of which are from the Bell System Practices Reference 518–114–119.

This volume may not be placed on sale in the Government Printing Office.

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NOTE: In this volume, the subject matter is developed by a series of student-centered objectives. Each of these carries a three-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see whether your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Introduction to Key Systems

NOT TOO MANY years ago a picture of a busy executive usually included a huge desk with several communications instruments. Their number and types gave you an indication of how important he was. In the same office today you see a different picture. One or two sophisticated instruments have replaced the many individual units, and the system is tailored to meet the special requirements of that particular office.

When a communications system is properly installed, the work of the using organization is simplified because such a system can save many steps and much time. The use of intercommunications systems, key telephone equipment, and private branch exchange (PBX) switchboards saves cable, instruments, and central office equipment. Because of these savings, base communications personnel can increase the telephone service of using organizations.

A variety of communications systems are in wide use by the Air Force. Individuals in the telephone equipment installation and repair specialist career field are responsible for the installation and maintenance of this equipment. We will discuss several systems in use at Air Force installations. This information will help you understand the operations, installation, and maintenance of these communications systems.

1-1. Key Telephone Equipment

Modern key telephones, in addition to providing specialized telephone service, present a better appearance and are more economical and versatile than the telephones used with the original systems. The former systems provided a specialized telephone service, but the stations were limited to a set arrangement because the features were grouped in certain combinations to form systems. The features included: pickup, hold, intercom, cutoff, and signaling. The present systems have all the advantages of the superseded system, but they also can have additional features. An example of the possible diversification is seen by considering a base commander's key telephone and that of his receptionist. The commander's unit may have an exclusion key, and the receptionist's may require a greater number of keys. You must consider each station as a separate problem and then select the equipment that satisfies the needs at each station.

The Air Force now uses 1A1 and 1A2 key systems extensively but key equipment is continually being expanded, modified, and improved. Consequently, you need to be prepared for variations in circuitry. This volume will familiarize you with the operation, installation, and maintenance of examples of key systems.

600. Given an illustration, identify an advantage of a key system, components for a typical system, and example services provided.

Key System. The 1A1 key system compares with a PBX in that the talking circuits are connected by an operated key. Of course, in this system the user operates the key, whereas an attendant operates the PBX keys. The typical system includes three to seven talking circuits distributed among 5 to 15 stations.

One big advantage of a key system is its flexibility. Probably no two installations are exactly alike in all service provisions. The talking circuits of a system may connect directly to a central office, a PBX, or a similar telephone system. A circuit is also available for a local intercom system with visual and audible supervision at each station.

Many other services may be provided by adding a particul unit to the installation. We use a typical 1A1 key telephone system (shown in fig. 1-1) for our explanation.

It is evident in this figure that the system consists of telephones, connectors, bridging terminals, a relay cabinet (which contains key units), and a power supply. The illustrated system has seven stations. Each telephone, through the connecting blocks and terminals, has access to four central office lines and one intercom line. Each circuit works because of the relay units of the equipment cabinet. A close examination of the individual components is necessary if we are to understand the system.

Exercises (600):

1. Given the information of figure 1-1, what is an advantage of a key system over regular telephone systems.

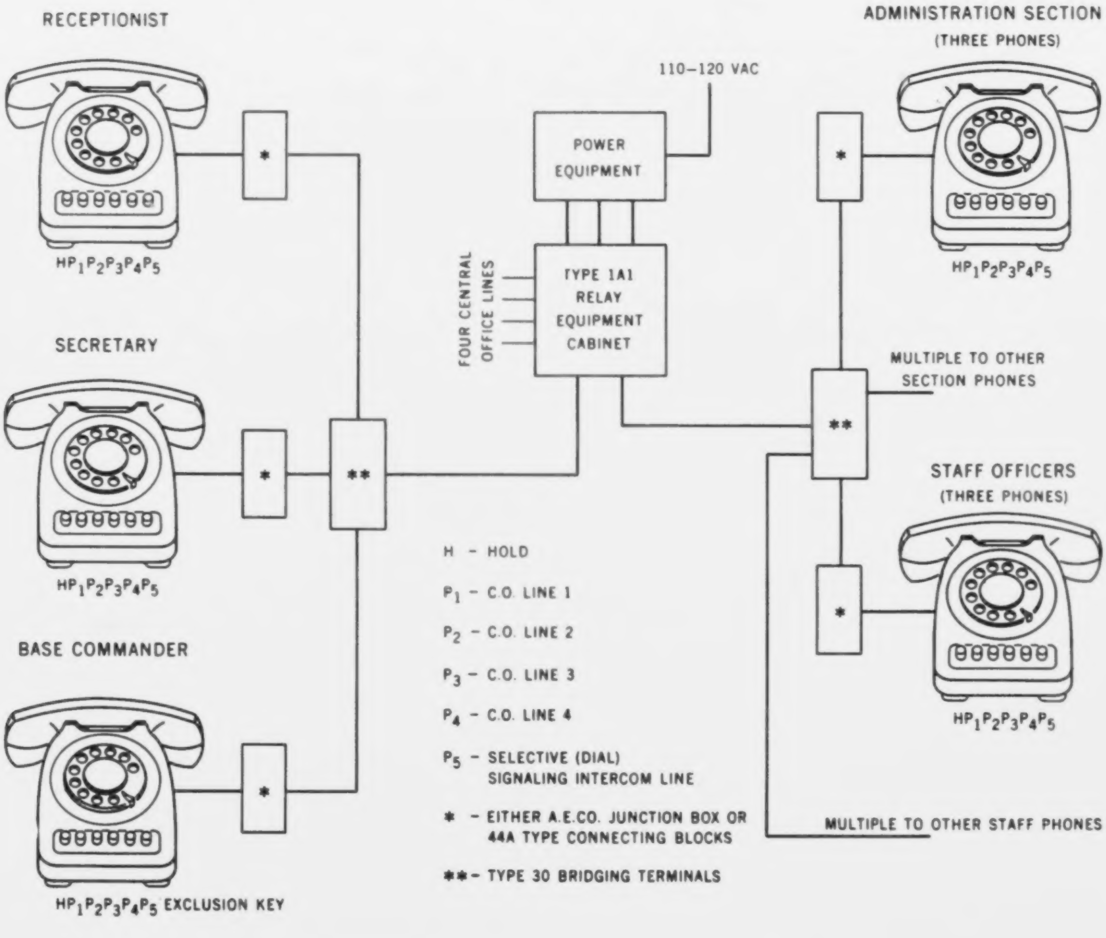
2. Using figure 1-1, identify two key components in each office.

3. Identify two major key system equipments normally installed together in the key system equipment room.

4. List four services offered by the illustrated key system (fig. 1-1).

601. State the purpose and identify compoments of a KTU, and cite the manufacturer's method for providing key telephone service flexibility.

Key System Equipment. If you refer again to figure 1-1, you can see that the incoming central office lines are connected to an apparatus and unit cabinet. This cabinet protects the key units and provides a mounting which allows access to the key telephon units (KTUs) for maintenance. Many different KTUs are provided, and each one has a specific function to perform; that is, it provides the relay apparatus needed to furnish the desired features in the key system. Each unit has a coded number which identifies the feature provided by that particular unit. Units may be combined, as required, for each installation Individual units


RECEPTIONIST
$HP_1P_2P_3P_4P_5$
SECRETARY
$HP_1P_2P_3P_4P_5$
BASE COMMANDER
$HP_1P_2P_3P_4P_5$ EXCLUSION KEY
110–120 VAC
POWER EQUIPMENT
FOUR CENTRAL OFFICE LINES
TYPE 1A1 RELAY EQUIPMENT CABINET
ADMINISTRATION SECTION
(THREE PHONES)
$HP_1P_2P_3P_4P_5$
MULTIPLE TO OTHER SECTION PHONES
STAFF OFFICERS
(THREE PHONES)
$HP_1P_2P_3P_4P_5$
MULTIPLE TO OTHER STAFF PHONES
*
**
H - HOLD
P_1 - C.O. LINE 1
P_2 - C.O. LINE 2
P_3 - C.O. LINE 3
P_4 - C.O. LINE 4
P_5 - SELECTIVE (DIAL) SIGNALING INTERCOM LINE
* - EITHER A.E.CO. JUNCTION BOX OR 44A TYPE CONNECTING BLOCKS
** - TYPE 30 BRIDGING TERMINALS

FEATURES

1. Four central office lines: P_2, P_3, and P_4 listed and intended primarily for incoming calls; P_1 unlisted and intended primarily for outgoing calls.
2. All telephones equipped with holding feature to facilitate transfer of calls and promote accuracy in handling of customer inquiries.
3. One dial intercom line, P_5, with line flashing for use by receptionist in forwarding calls and for general office purposes.
4. Base Commander's telephone equipped for exclusion on central office line, P_1.

Figure 1–1. Typical key system.

that are assembled and wired at the factory—and are then combined, interconnected, and prepared for connection to the cable—are known as package units. The trend is to order packaged key telephone systems. Since many varied services can be requested, the packages are available in a variety of sizes and features. Thus, we can have flexibility. One package unit is coded as the 200G series. It includes the units that provide pickup and hold features on four to nine central office lines, or the pickup and hold features on four to seven lines with a nine-station dial selective intercommunicating circuit. Audible signaling is provided by an electromechanical interrupter, and visual signaling is done with flashing and winking lamps. Also, a manual intercom circuit is included with the package unit. In addition, the package includes a 75-pair inside wiring cable that is terminated at the terminal plate assembly and the KTUs.

NOTE: The full number for a package would be 200G7DC. The 7 discloses the number of central office or PBX lines. The D identifies it as having a nine-station dial selective intercommunicating circuit, and the C denotes that the cable and cable terminal are wired to the unit.

Other package units were developed before the 200G series package, and package units are being or have been developed to replace them and the 200G series. For example, a 300 series package is replacing the 200G series. You must realize that you can be responsible for obtaining, installing, and maintaining the components of any of these packages of the complete package unit.

We know, then, that individual KTUs are combined to make a package. You will see differences in every type of KTU. Since each type serves a specific function, we will not illustrate all KTUs that provide this service, but only one or two. As a result, you will gain some familiarity with key equipment.

Exercises (601):

1. What is the purpose of key telephone units?

2. Identify a component(s) to be noted in a key telephone unit.

3. Describe the method by which a manufacturer provides key system flexibility.

602. Given a specific KTU, identify its function, feature, or characteristic.

Central office or PBX line unit. This KTU provides equipment for one line. It consists of connecting terminals, relays, rectifying devices, capacitors, and resistive devices (resistors, thermistors, or varistors) (fig. 1-2) which provide pickup, hold, power failure, and visual supervision on central office or PBX lines. Refer to figure 1-2. (NOTE: Although the KTUs may be manufactured by two or more manufacturers, when these KTUs have the same number, they also have identical circuits and identical connections. Therefore, any unit can replace another having the same number. It is probable, though, that the circuit components are not interchangeable even though the key unit is.)

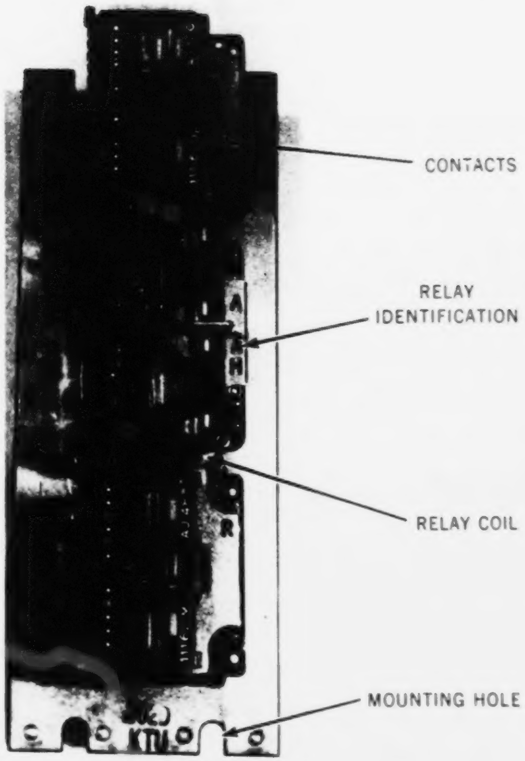


Figure 1-2. 202D line unit.

Combined CO or PBX line unit. The apparatus of this KTU includes equipment for more than one line. The exact number of lines is dependent on the particular unit. The components are exactly like those of the 202D, but multiplied. The 230B KTU shown in figure 1-3 provides four lines identical to the 202D shown in figure 1-2.

Interrupter and control unit. This KTU (fig. 1-4) furnishes intermittent ringing, time-out, and flashing and winking lamp circuit features for the key system. Figure 1-5 shows a 232B unit which is used in conjunction with a 230B, or other multiline units, such as the 239 KTU which provides 9 CO lines.

Dial selective intercom (207C). Selective signaling for up to nine (single-digit) stations connected for intercom is provided by this KTU, but only one common talk link, however. Figure 1-6 shows the 207C KTU. (Note the rotary stepping switch which enables you to make the selections.)

Common equipment circuit. This KTU provides common audible signal control on incoming calls and battery feed and noise suppression for a manual intercom circuit.

Power unit. A variety of voltages are provided by the various power units available. For example, two different

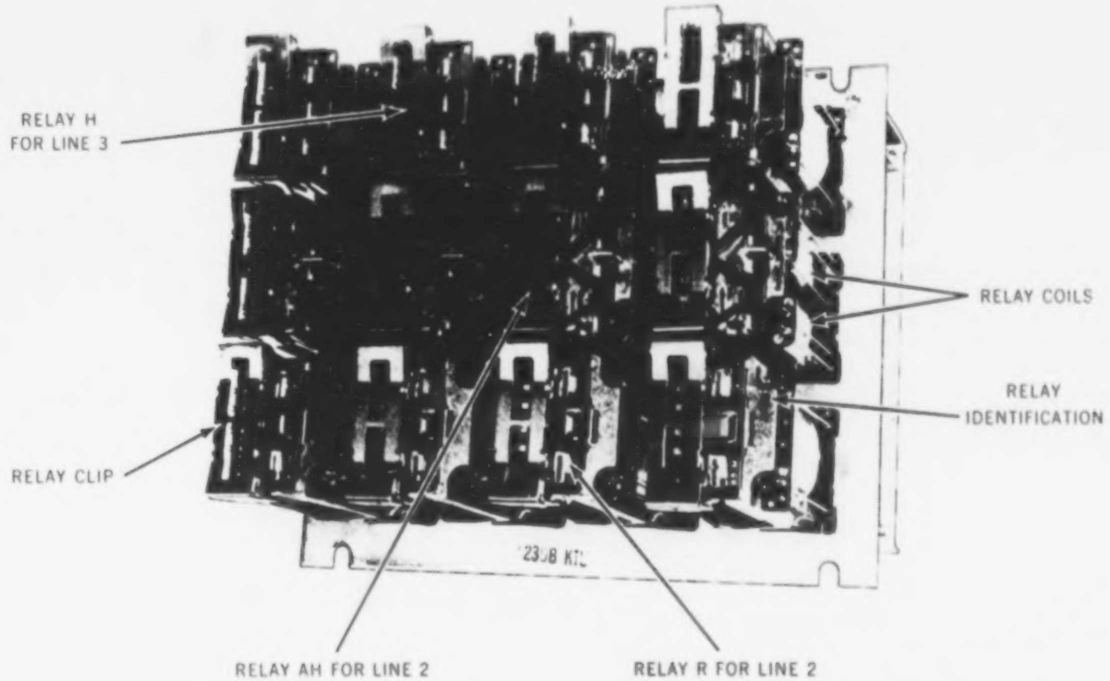

RELAY H FOR LINE 3
RELAY COILS
RELAY IDENTIFICATION
RELAY CLIP
230B KTU
RELAY AH FOR LINE 2
RELAY R FOR LINE 2

Figure 1-3. 230B combined CO or PBX line unit.

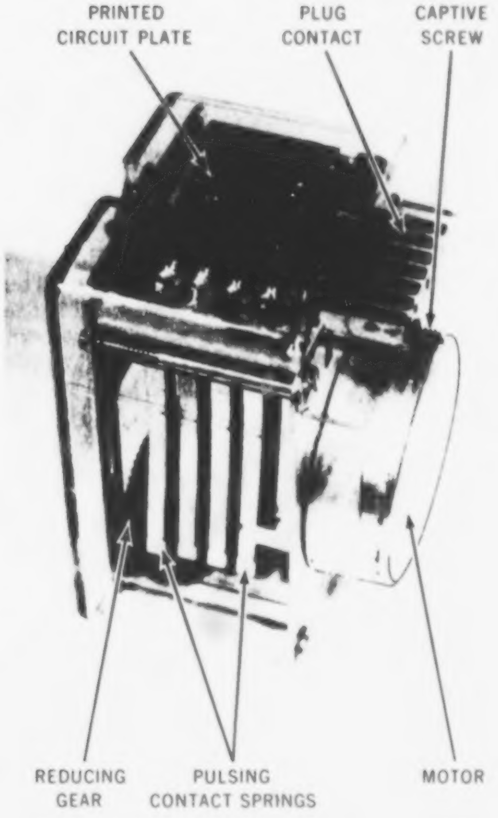

PRINTED CIRCUIT PLATE
PLUG CONTACT
CAPTIVE SCREW
REDUCING GEAR
PULSING CONTACT SPRINGS
MOTOR

Figure 1-4. KS-19175 interrupter.

DC supplies are required for relays and transmission. Three separate AC outputs are necessary for bells, buzzers, and lamps. The power unit needed for a particular system must be selected from the Bell System Practices or an applicable technical order. The many different type units make it impractical for us to discuss individual units at this time.

It is apparent from the illustrated KTUs that all associated units appear very similar. To illustrate, the 202D, 230B, 232B, and the 207C have the same type of chassis, the relays appear to be the same, the capacitors are likewise comparable, and the mounting hole spacing is identical. The units have to be alike regardless of the manufacturer because each unit is installed on the same mounting frame (apparatus mounting). Widths vary according to unit. We have discussed a few KTUs and a sample package. However, there are many variations in key systems. You must determine the subscriber's needs and select the appropriate equipment for each individual installation.

Exercises (602):

1. What is the function of the typical central office single line unit?

2. Identify two features (services) provided by the typical interrupter unit.

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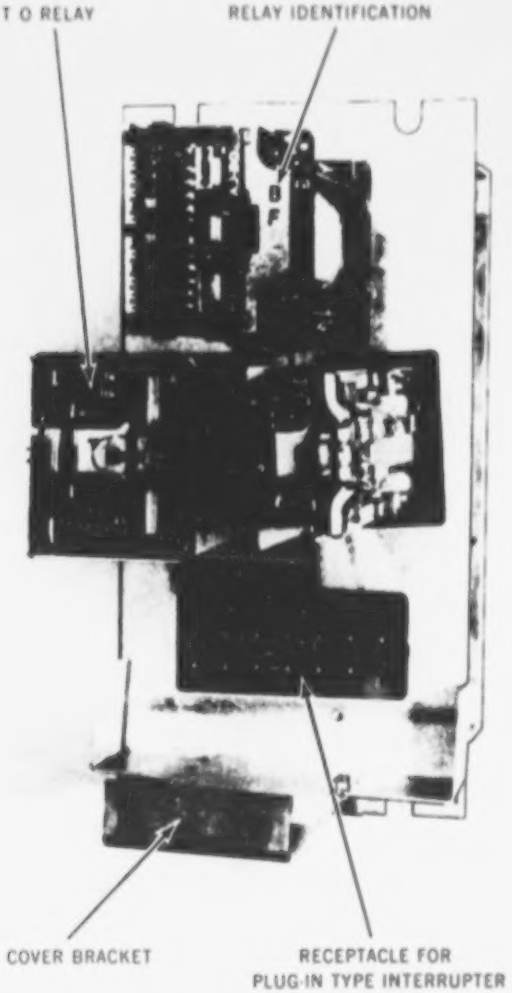

Figure 1-5. 232B interrupter and control unit.

3. Give the prime service provided by the 207C KTU.

4. What two types of power are provided by the key system pow unit?

603. Compare the 1A2 key system to the 1A1 key system by denoting two differences and two advantages.

1A2 Key System and 1A1 Key System. The 1A2 system provides the same functions as did the 1A1 system. You can also order dial intercom as a unit of the package; 1A2 packaged units are referred to as "key service units" (KSUs). The major advantages that a 1A2 package has over the earlier package is its miniature size and its simplicity when you are restoring a unit to operation. The 1A2 unit (400D) is approximately 4 inches high and 1 inch wide. In the same manner, the KTUs used in association with the 400D are miniaturized. The line circuits are printed on plug-in cards and use transistors and miniature relays. Hence, the card is easily removed and replaced during a troubleshooting procedure. Although the circuits and equipment are new, you can still use the same key telephones.

The 1A2 key telephone system (KTS) features various combinations of prewired systems available in KSUs and panels. These packages permit a wide latitude in installation flexibility. Some packages are available with interrupters, power units, connecting blocks, and floorstands. KSUs are designed primarily for small-to-medium size 1A2 KTS installations; panels are designed for large or centralize installations. Figure 1-7 shows a KSU that provides 4 CO lines.

One of the most popular KSUs is the 513A3, which provides 8 CO lines. This system is sometimes expanded to 16 lines by the addition of a 514, then referred to as a 515 KSU. To provide intercom, it is necessary to sacrifice one CO line. After determining the specific needs of a subscriber, refer to the applicable technical order or reference guide for the appropriate package or panel. Figure 1-8 shows 1A2 KTUs and their function. It also shows an

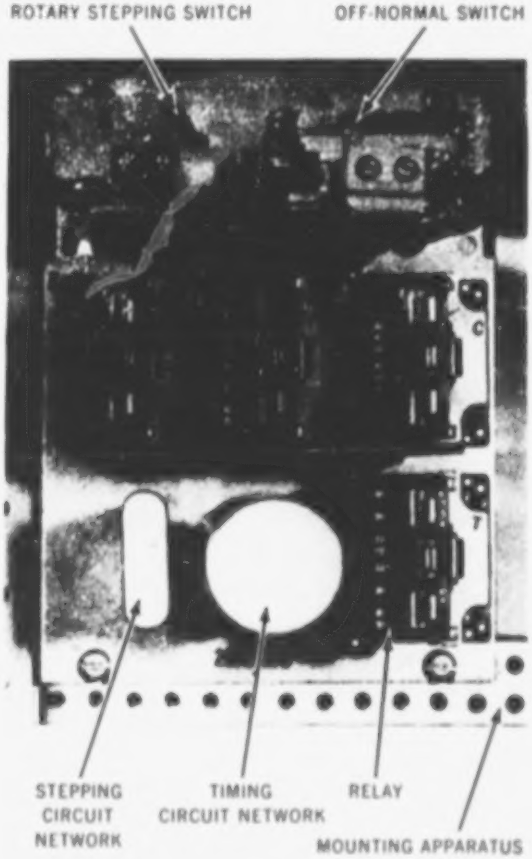

Figure 1-6. 207C dial selective intercom unit.

arrangement of KTUs within the 513, 514, and 515 KSUs mentioned earlier. Most of 1A2 key systems installed to date could be built from the information of figure 1-8; however, it is wise to consult the applicable technical order or reference guide.

To illustrate use of figure 1-8, note that if you want to install a 10-code circuit dial intercom KTU you order the 407B. The flashing lamp circuit to order for that intercom should be the 425B KTU. As noted before, the line circuits to use in conjunction with the intercom are the 400 series CO/PBX line KTUs.

The 407B requires two 40-pin connectors, as does the 425 KTU. However, the 407B is shown under the 513 KSU listing while the 425B is in the 514 KSU listing. The 400 series KTU requires one 40-pin connector.

Figure 1-9 is a picture of the 515A3 KSU with the cover removed. You can now see more readily that the 515 is a supporting unit for the 513 and 514. In addition to the line and intercom KTUs we mentioned as installed on the 513 KSU, you can see a fuse panel, a power unit, a designation strip, interrupter sockets, and additional KTUs. The 514 KSU is shown with no KTUs installed. It is used with the 513 to provide expansion. If you recall, we identified the 425B as being on the 514; this flashing lamp circuit, then, is an expansion feature.

Figure 1-9 identifies one of the connectors for the 514 as 914A. Figure 1-10 shows this connector separated from the KSU. Accordingly, there are two connectors attached to the apparatus and the wiring from the socket pins is fanned out at the rear and then tied into a cable that is extended over the 515 KSU backboard. Figure 1-11 is an open view of the 515 KSU and this backboard is identified in the figure. You can also see four 66R connecting blocks installed, as well as the interwiring between them.

Above, we stated that the large or centralized key system is installed on panels. A typical such panel is illustrated in figure 1-12. It shows thirteen 400 series KTUs installed on a 584C panel. The KTUs may be intermixed in any connector position. In addition, you can see a KS-type interrupter installed at the right of the line units. (NOTE: The illustration shows the rear view of the panel.) On the back of the panel is the fuse and terminal field and cable tie brackets. Pictured are

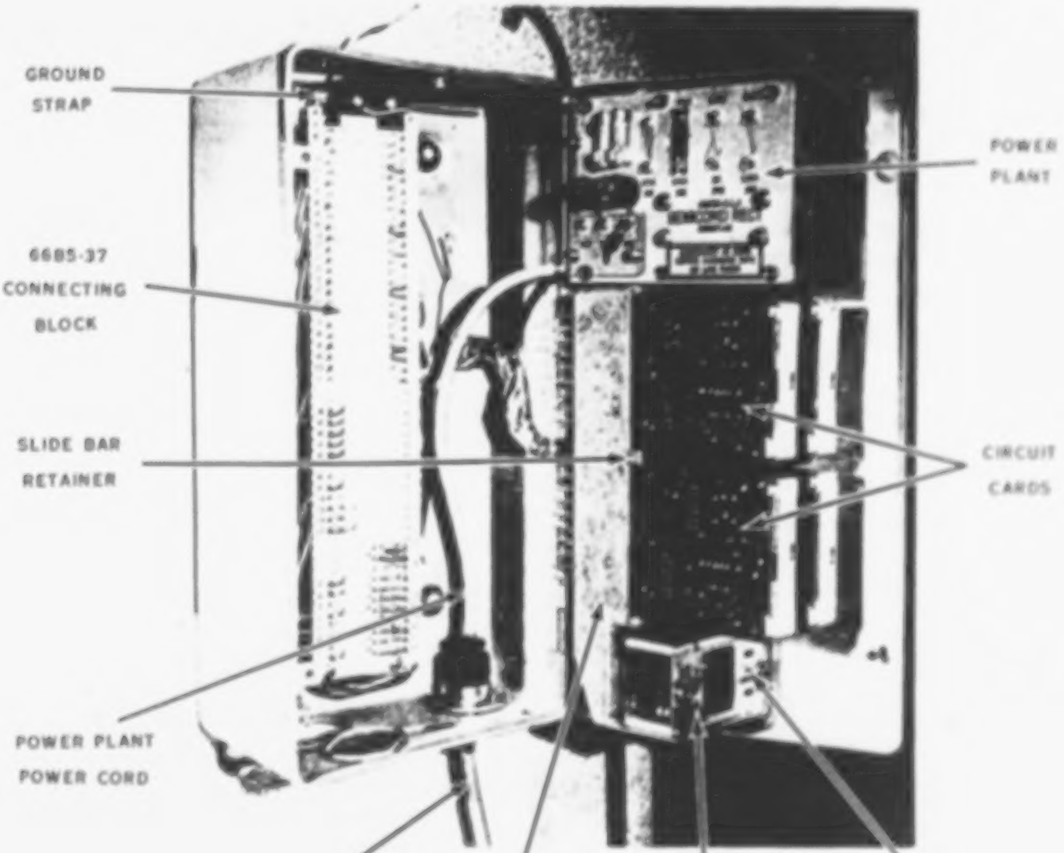

Figure 1-7. 551A key service unit.

ARRANGEMENT of 400 SERIES KTUs IN 513, 514, AND 515 TYPE KSUs

KTU	SIZE (IN)	PINS	SERVICE FUNCTION	515 KSU															
				513 KSU								514 KSU							
				J1 40 PIN	J2 40 PIN	J3 20 PIN	J4 20 PIN	J5 20 PIN	J6 20 PIN	J7 40 PIN	J8 40 PIN	J11 40 PIN	J12 40 PIN	J13 40 PIN	J14 40 PIN	J15 20 PIN	J16 20 PIN	J17 20 PIN	J18 20 PIN
400D	4	18	CO PBX Line Ckt	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
400E	4	18	CO PBX Line Ckt	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
401A	4	18	Manual Intercom Ckt	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
406A	4	10	Diode Matrix	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
407B	8	80	Dial Intercom 18-Code Ckt	●		†	†	†	†	†	†	†	†	†	†	†	†	†	†
412A	4	18	Auto Ring-Up Ckt	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
414A	4	20	Ringdown Tie Line Ckt	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
415A	4	18	Auto Tie Line Ckt	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
416A	4	20	Station Tie Line Ckt	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
417A	4	40	Add-On Conf Ckt	†	†	†	†	†	†	●	●	¶	●	¶	●	†	†	†	†
418A	4	20	Short Range Tie Line Ckt	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
419A	8	80	Auto Ringdown Tie Line Ckt	●		†	†	†	†	†	†	●		●		†	†	†	†
420A	4	18	Dial Intercom Long Line Ckt	†	†	●	●	●	●	●	●	●	●	●	●	●	●	●	●
421A	4	40	Power Failure Transfer Ckt	✱	✱	†	†	†	†	●	●	✱	✱	✱	✱	†	†	†	†
422A (MD) or B	4	40	Dial Intercom Button Busy Ckt	†	†	†	†	†	†	●	●	●	†	●	†	†	†	†	†
423A	4	20	Dial Intercom, Aud Tone, Dial Tone, Busy Tone Ckt	†	†	●	●	●	●	●	●	●	●	●	●	●	●	●	●
424A	8	80	Dial Intercom, 18-Code Ckt	●		†	†	†	†	†	†	†	†	†	†	†	†	†	†
425A (MD) or B	8	80	Dial Intercom Flashing Lamp Ckt	†	†	†	†	†	†	†	†	●		●		†	†	†	†
426A and 427B Series 9 or 427C	8	60	TOUCH-TONE Adapter Ckt	†	†	†	†	†	†	†	†	●		†	†	†	†	†	†
	8	80	TOUCH-TONE Adapter Ckt	†	†	†	†	†	†	†	†	†	†	●		†	†	†	†
428A	4	40	Multiline Exclusion Ckt	§	§	§	§	§	§	●	●	●	§	●	§		§	§	§
429A	4	40	Tap Hold Detector Ckt	†	†	†	†	†	†	●	●	†	†	†	†	†	†	†	†
430A	4	20	Flutter Generator	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

● Usable on indicated connector

✱ Restricted to transfer of one station ringer

† Not usable

‡ Partial use (4 X 3)

§ One circuit only

¶ Spare terminals for 13 leads required on connecting block

HI-088

Figure 1-8. Arrangement of 400 series KTUs.

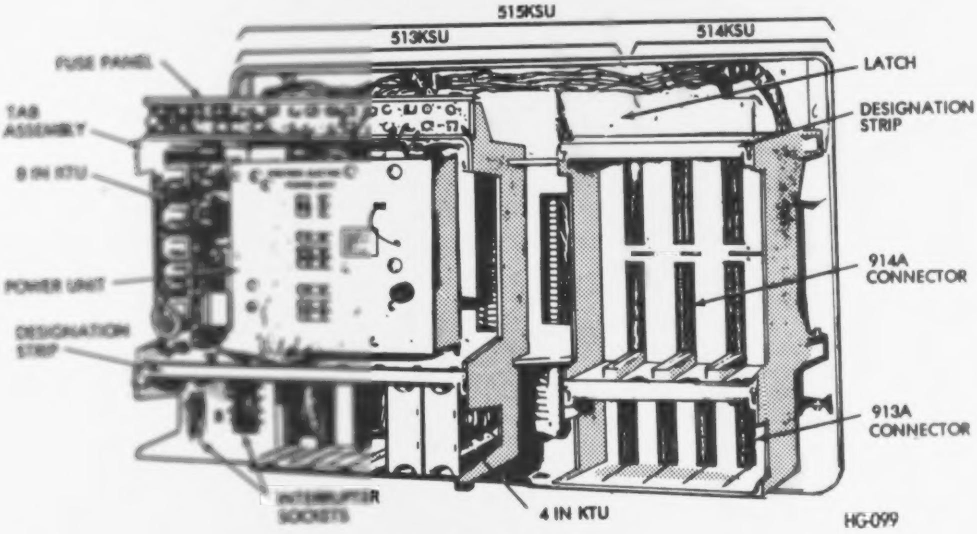
515KSU
513KSU
514KSU
FUSE PANEL
TAB ASSEMBLY
8 IN KTU
POWER UNIT
DESIGNATION STRIP
INTERRUPTER SOCKETS
4 IN KTU
LATCH
DESIGNATION STRIP
914A CONNECTOR
913A CONNECTOR
HG-099

Figure 1-9. 515A3 KSU.

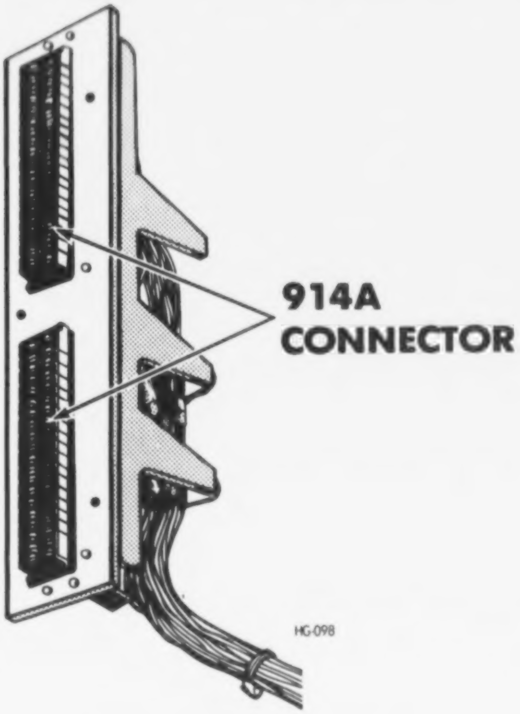
914A
CONNECTOR
HG-098

Figure 1-10. 69E apparatus mounting.

twenty-two fuses: 5 ampere type, 2 ampere type, 1⅓ and 1/2 ampere fuses. All line and station wiring is factory wired at the rear of the panel (wiring is not shown on fig. 1-12). The program A option plug is used to provide interrupted lamp signals, if requested. There are also panels available for providing mounting for auxiliary KTUs for a large system. For example, a 597A panel permits the mounting of fourteen 400 series KTUs in any combination.

Exercises (603):

1. Compare the line units of text figures 1-2 and 1-7 and identify a difference to be noted.

2. Compare the relays of the 1A1 and 1A2 key systems.

3. Tell two advantages of the 1A2 key system over the 1A1 system.

604. State two features provided by a 6A key system and identify three typical units for it.

6A Key System. Although the 6A key system is complete within itself, it is used with 1A1 to provide intercom only. The most commonl used 6A is manufactured by Western Electric; however, Auto Electric Company makes a comparable system which they call 16A. The units cannot be intermixed. Stromberg-Carlson's SC6A provides the same services and will readily intermix with 6A.

The features and capabilities will differ from system to system depending upon the subscriber's needs. However, we may describe the average 6A system as being an intercommunications system, used with 1A1 or 1A2, equipped to provide 2 private talk links, selective signaling for 18-station (Max 36), camp-on control, and visual supervision. The following KTUs would be required to make up this "average" system:

- 222A - 2 talk links with common equipment and 9 Station
- 223A - 3 additional station CKT (3 required)

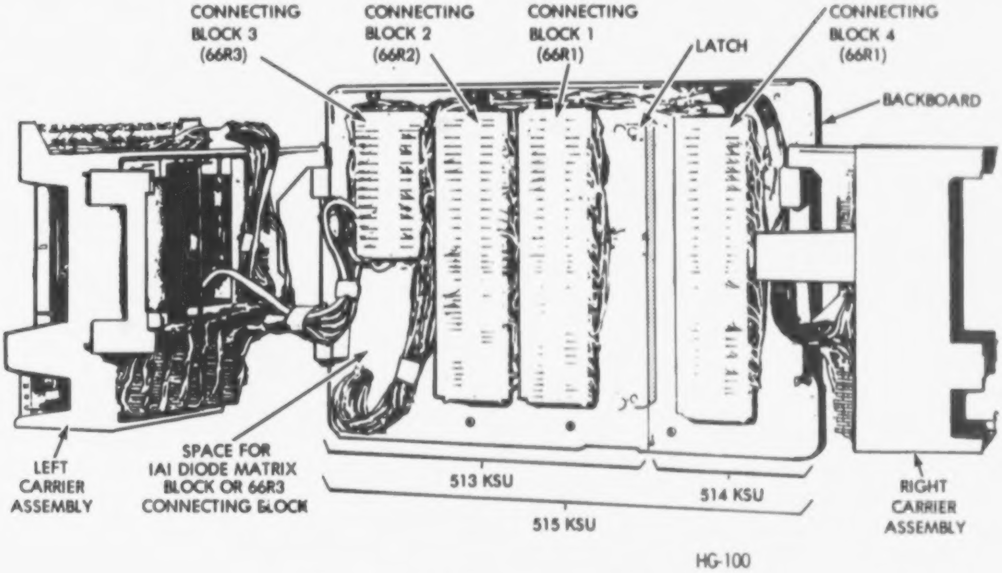
CONNECTING BLOCK 3 (66R3)
CONNECTING BLOCK 2 (66R2)
CONNECTING BLOCK 1 (66R1)
LATCH
CONNECTING BLOCK 4 (66R1)
BACKBOARD
LEFT CARRIER ASSEMBLY
SPACE FOR 1A1 DIODE MATRIX BLOCK OR 66R3 CONNECTING BLOCK
513 KSU
514 KSU
515 KSU
RIGHT CARRIER ASSEMBLY
HG-100

Figure 1-11. 515 KSU, carrier assemblies open.

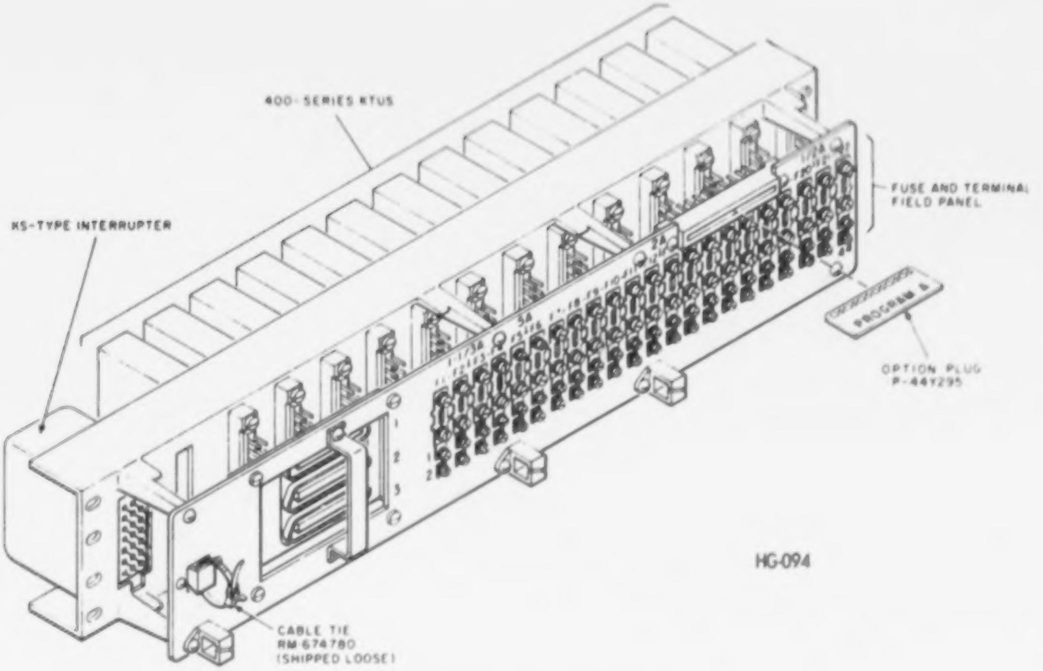

Figure 1-12. 584C panel, rear view.

- 207C - Dial selective signaling circuit (Max 9 Sta)
- 216A - TRANSFER unit (expands 207C from 9 to 18 Station)
- 224A - CAMP-ON CONTROL
- 217A - PRESET CONFERENCE

Many additional add-on features are available, such as add-on conference, and long-line circuit, which we do not have time to discuss.

The 6A system comes prewired for 18 stations but can be expanded to a maximum of 36 stations. The most frequently used package is the 200H18DC, which we referred to earlier as an "average" system. Since this 6A system is standard, you will do little or no 'building' of 6A systems. Consequentl we will not go into detail on possible arrangements.

Exercises (604):

1. Identify the talking feature provided by the 6A system that differs from the 1A1 and 1A2 systems.

2. Identify the peculiar signaling feature provided by the 6A key system.

3. Tell the nomenclature of the 2-talk link KTU.

4. Give the nomenclature of the CAMP-ON CONTROL KTU.

5. Tell the nomenclature of the PRESET CONFERENCE KTU.

1-2. Key Telephones

The 565 telephone is one in the 560 series of key telephones. The Air Force has many variations of several key telephones. We have chosen the 565 for our discussion because it adequately represents the 560 series key telephon Essentially, it is a 500 type telephone, discussed in a previous volume, with addition of the circuits for the keys. The talking, ringing, and receiving circuits are the same as those of the 500 type. These key telephones have keys for pickup, holding, signaling, cutoff, and intercommunicati The keys are located in the lower front part of the telephone set and are illuminated for signaling and for busy indication. When more than one line terminates in a set, the ringer may be connected to any one line or, with additional equipment, be made common to all lines. All mounting cords have amphenol connectors.

The pushbuttons shown below the dial in figure 1-13 (which is an illustration of a base commander's set) move springs on keys placed below them. These springs are also illustrated in figure 1-13. The PICKUP keys switch the set's

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talking circuit to one line. The depressed pushbutton locks down and, in addition, restores any other depressed pushbutton to the normal position. Thus, an interlocking device between the keys prevents two keys from being operated simultaneously. A lamp within the operated pushbutton glows to indicate the busy condition. By pressing the HOLD pushbut you keep the line connection while performing another function. Release of the HOLD pushbutton restores the operated PICKUP pushbutton. The figure includes an explanation on the operation of the EXCLUSION key, which permits the user to cut out all stations of that system for that central office line. Exclusion is normally effective on only the line connected to the first pickup key. Following the operation of this key, the operator of the key can talk to the outside line party without being heard or interfered with by other persons in the system.

605. For given key telephones, identify their features, sample connections, and typical specifications or identifying characteristics.

The 565 key telephone is identified by a code. Figure 1-14 illustrates its code and its features. The identification number contains two or three letters, in addition to three digits. Each digit and letter indicates a characteristic of the set. For example:

First digit. The 5 of this position indicates that the set has the components of the 500 type telephone.

Second digit. The second digit is always a 0, 1, 4, or 6 and indicates the number of pushbuttons on the set. There were a few sets having 7 as a second digit. This set had three pickup keys, three hold keys, and one key for operating a buzzer circuit.

Third digit. The third digit is always a 0, 1, 4, 5, or 8 and indicates some of the features built into the set. Other features are indicated by letters.

(1) A 0 indicates that the set has neither exclusion nor lamps.

(2) A 1 indicates exclusion but no lamps.

(3) A 4 indicates lamps but no exclusion.

(4) A 5 indicates lamps and exclusion.

(5) An 8 indicates that the set is designed for use with 4-wire service.

First letter. The first letter indicates the arrangement of the keys. This letter is arbitrarily assigned and has no significance except as assigned in the identification chart As an example, the first letter, L, for the 565LB telephone indicates that the phone has CUTOFF and HOLD buttons. Also, it indicates that the phone is usable with "hands off" equipment.

Second letter. Originally, the second letter indicated whether the set was constructed with or without a dial. An "A" identified it as manual type and a "B" identified it as having a dial. All sets are now shipped with a dial; hence no code is needed. Of course, you may see sets that have the former identification. The second letter on the most modern sets will indicate another variation which may have different meanings. Again, the manufacturer determines the indicator and its meaning.

NOTE: Touch-tone telephone coding differs from what we have shown in figure 1-14. The 1564HL is one of these telephones. In this case the 1 indicates that the telephone is a touch-tone type (using pushbuttons for dialing). It also has one HOLD and five PICKUP keys, as indicated by the 6. The 4 indicates some of the features of the set, and the letter

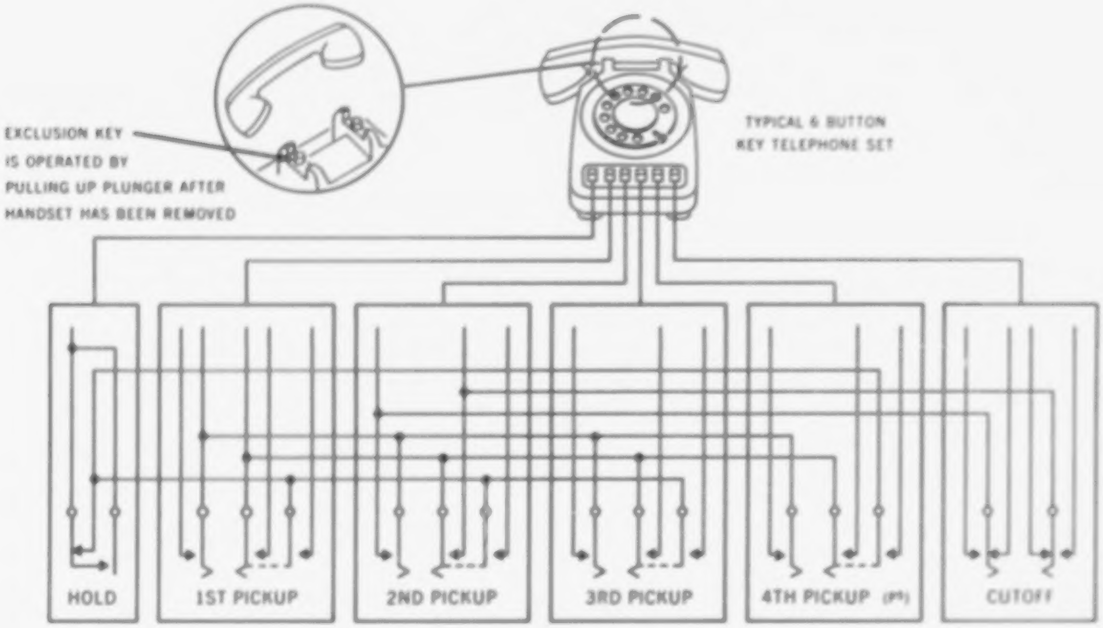

Figure 1-13. Key telephone set pushbutton and switch arrangement.

reveal other features. This telephone won't work with the 207C dial intercom unit; thus it must be used with a touch-tone adapter unit if the 207C is a part of the system.

Since almost any desired feature combination can be furnished to a station, you should study your requirements and select the equipment that meets those needs. Let us consider the features of the sets illustrated in figure 1-1.

It is evident that the communications officer ordered for the base commander a set containing the EXCLUSION key, a HOLD pushbutton, and five PICKUP keys. Figure 1-14 shows us that this set must be 565HK (565HB and 565GB, having most of the same features, are no longer being manufactured, as indicated by the MD in the rating column). However, the exclusion switch for the set would have to be ordered separately although the plunger would be in the telephone case. In addition, figure 1-1 discloses that key P_1 is connected to an unlisted central office line. Since the line is not listed in the directory, few incoming calls will be received through this circuit. Consequently, as stated in figure 1-1 the line is intended primarily for outgoing calls. Of course, the outgoing and incoming lines could have been assigned to any of the "P" keys. The remaining telephones of figure 1-1 have no exclusion feature; therefore, they are coded 564HD. All of the telephones have the holding feature; thus the user can answer a call on a line without disconnecting a second line which has a call in existence.

Figure 1-14 shows two additional key systems features. The CUTOFF button is a circuit device which permits the user to disconnect or connect to an extension or an extension ringer. The second feature is shown only for the MD telephones therefore, it may not be available now. It is the SIGNAL (S) button. All stations must have an audible signaling device. For a less noisy signal, you may install a buzzer instead of a ringer.

A steadily glowing lamp indicates that the call has been answered or is an outgoing call. A flashing lamp indicates that the call is incoming. A visual signal also is used in conjunction with the HOLD pushbutton: This lamp operation is referred to as a "wink." (The "wink" feature provides a long ON period and short OFF period.) Pressing a PICKUP button releases the holding circuit and returns the lamp to a steady glow again.

Exercises (605):

1. What is the name for the key system feature that connects the talking circuit of the key telephone to the central office line?

2. What type connection in the key set permits the feature of exercise 1 to be effective?

3. Tell the feature designated by the 8 of the 568HF telephone.

4. Tell the two evident differences for telephones 565LD and 565HD.

5. How many PICKUP keys should you see on a 565HK key telephone?

KEY BUTTON ARRANGEMENTS	FEATURES					CODING		
	EXCL KEY	ILLUMINATED KEY BUTTONS	STATION BUSY LAMP CONTROL	SPEAKERPHONE CONTROL	PLUG-IN CORDS	MANUAL	DIAL	RATING
HPPP						540BA	540BB	MD
HPPP		X				544BA	544BB	MD
HPPP^S	X	X	X			545BA	545BB	MD
PPPP^S		X				544AA	544AB	MD
HPPPPP		X				564BA	564BB	MD
HPPPPS		X				564CA	564CB	MD
HPPPSS		X				564DA	564DB	MD
HPPP^{S}P^{S}P^S		X	X			564HA	564HB	MD
HPPP^{S}P^{S}P^S	X	X	X			565BA	565BB	MD
HPPP^{S}P^{S}P^S	X	X	X	X		565HA	565HB	MD
PPPP^{S}P^{S}P^S	X	X	X			565AA	565AB	MD
PPPP^{S}P^{S}P^S	X	X	X	X		565GA	565GB	MD
HPPPP^{S}C	X	X	X			565EA	565EB	MD
HPPPP^{S}C	X	X	X	X		565LA	565LB	MD
HPPP^{S}P^{S}C	X	X	X	X	X		565LD	
HPPP^{S}P^{S}P^S		X	X	X	X		564HD	
HPPP^{S}P^{S}P^S		X	X		X		564HL	
HPPP^{S}P^{S}P^S	X	X	X	X	X		565HK	
HPPP^{S}P^{S}P^S	X	X	X		X		568HF	

H = Hold (Nonlocking)
P = Pickup (Locking)

S = Signal (nonlocking)
C = Cutoff (Turn button)

P^S = Convertible, either pickup (locking) or signaling (nonlocking)

Figure 1-14. Identification codes for key telephones.

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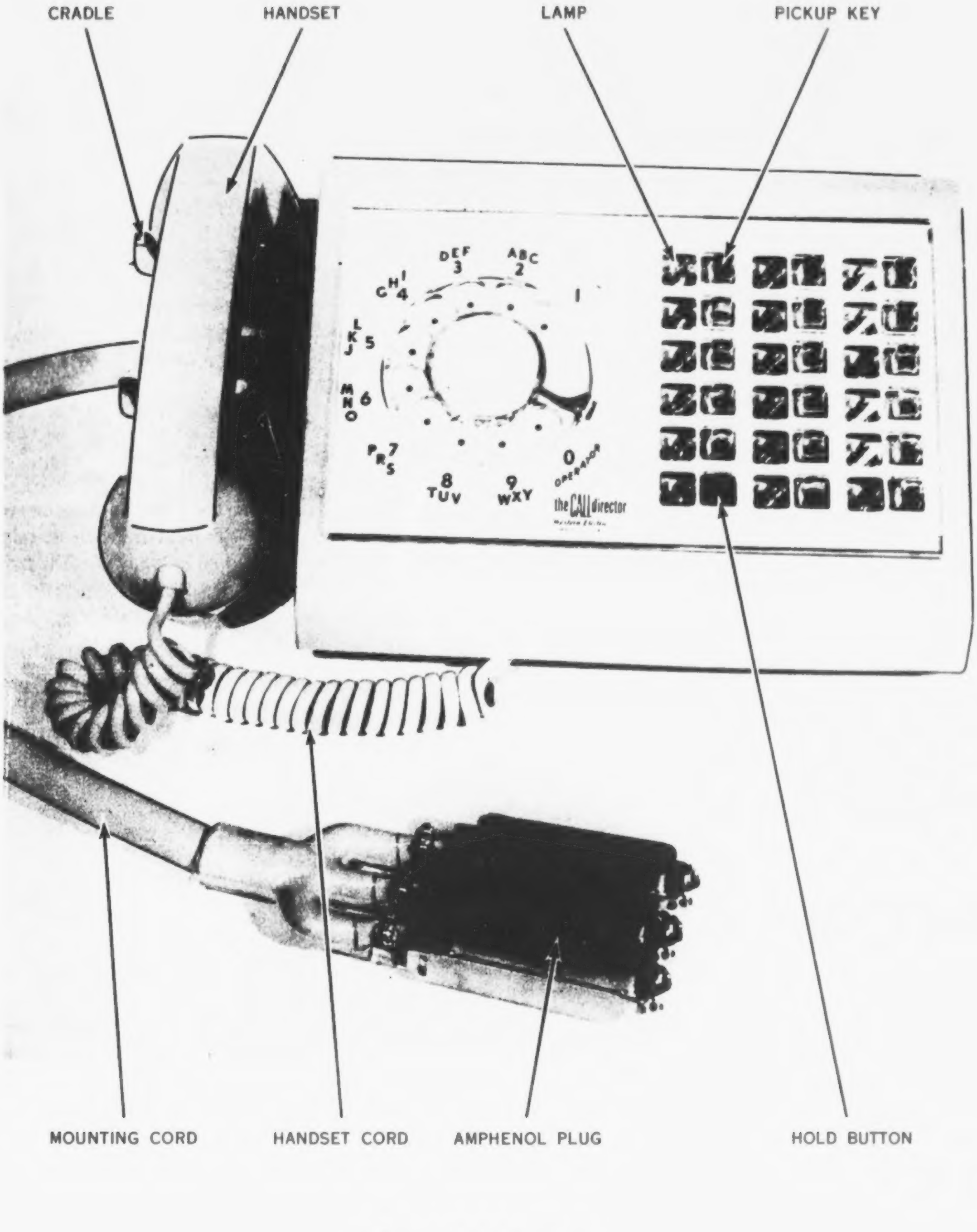
CRADLE
HANDSET
LAMP
PICKUP KEY
the CALL director
MOUNTING CORD
HANDSET CORD
AMPHENOL PLUG
HOLD BUTTON

Figure 1-15. Call director set.

6. You operate which pushbutton to cause a lamp to "wink?"

606. Compare two common multibutton key telephones and indicate a typical use for them.

Another multibutton phone used extensively is the Call Director, made by the Western Electric Company (WECO). It provides the same services as the 560 series telephone. However, it will accommodate up to 30 lines. The most commonly used sets are the 630 and 631. The 630 type comes equipped with 12 lines, but can be expanded to 18 by the addition of a 598A (see fig. 1-15). The 631 may be expanded to 30 buttons. The Automatic Electric Company make an equivalent set, the Call Commander. Either set is in reality only a key telephone with 12 or more buttons instead of 6. The talking circuits of the Call Director set are identical to those used in the 560 series sets. There is a difference in the construction of the switches operated by the pushbuttons, but the job they do is the same.

Either the Call Director or Call Commander can be used with the 1A1 system. When used with this system it is generally used by a receptionist who answers all calls. The system will have to be large to make the use of the Call Director economical. Sometimes it is used in combination with two or more systems, with one attendant answering all calls and using the intercom feature to distribute the calls to those concerned. Some Call Directors are designed to accept either two or four wire circuits; however, we will not have time to discuss individual sets.

Exercises (606):

1. Describe the difference(s) between a Call Director key telephone set and a 565 key telephone set.

2. What is the most practical use for a Call Commander (Call Director) key telephone?

CHAPTER 2

Theory of Key System Operation

YEARS AGO a telephone caller originated a call by turning a generator handle, lifting a handset, and requesting an operator to make the connection. After the call was completed, the originating party was required to rering the operator. Analysis of this calling procedure revealed that time and effort would be saved if the lifted handset would automatically indicate to the operator a need for assistance, and the restored handset would likewise identify the call as being completed. The dial and additional improvements further increased the efficiency of the telephone system.

We learned that a key system provides greater organizational efficiency. This would not be true if the personnel were unable to operate the equipment. The operating procedures are not difficult, however, because they are familiar actions. For instance, you lift a telephone handset as one of the initial actions. In addition, you press a pushbutton. These two steps are used regardless of the key system. Dialing a number may be a subsequent procedure. Of course, this last act should offer no challenge to you either.

Knowing the operating procedures is not enough, though. If you are to be considered an efficient repairman, you must know the principles that permit the equipment to function. Hence, you must understand what is happening when you lift the handset and depress each pushbutton. Some results are also familiar because we described similar effects in the earlier volumes. For example, in a previous volume was a description of the results of your removing the telephone handset from its cradleswitch, thus lighting a busy lamp. The method by which the lamp is lighted can vary, however. Of course, it lights because an electric circuit is completed. In this chapter we interpret schematics to find out how electrical circuits in a telephone system are completed.

2-1. Schematics and Their Interpretation

Since the 230B is the most common CO line unit, we use it for our discussion. This same circuit explanation will apply to the 202D, 238A, 239A KTUs.

607. Given a sample schematic diagram, identify functions of specific devices and interpret selected circuits.

Since the operation of the 230B KTU controls the operation of the 232B, and the operation of the 232B controls the audible and visual signals at the telephone through the 230B, it is necessary that we discuss the two units at the same time.

To trace a circuit on a schematic the circuit must be complete, from one side of the power supply to the other. The positive side of the battery supply is shown on foldout 1 as GROUND: the negative side of the battery supply is shown as BATTERY. Any circuit tracing must start at one and stop at the other.

In some of the circuits to be traced and discussed, the only known point from which to start is the middle of the circuit. In this case you trace one way, or the other, to find either BATTERY or GROUND. Having found either BATTERY or GROUND, the circuit must be retraced to the starting point and on, until the other side of the power supply is reached. We are establishing continuity only; current flow will be considered as being from negative to positive when continuity has been established. In association with the circuit descriptions, you will find sequence charts and operational sketches used. You may, while reading the circuit description, refer to the operational sketches and sequence charts for verification.

In the following paragraphs, the circuits controlling each relay, and the circuits controlled by each relay, of both the 230B and 232B KTUs, will be discussed and analyzed. In the discussion of the circuits, each contact will be covered, in turn, from bottom to top, as they are drawn in the schematic of foldout 1.

Exercises (607):

Use foldout 1 to answer the following exercises.

1. Identify the relay and its contacts that complete the operating circuit to the ST relay in the 232B KTU.

2. The contacts of what relay control audible signaling to the 202D KTU?

3. Identify the terminal of the 232B having positive potential.

4. Identify the negative potential terminal for the 230B KTU.

608. From a given schematic diagram, interpret a specific connection, symbol, and feature illustrated.

Foldout 1 shows the circuits of the 230B KTU and the wiring connections to a 564HL telephone. All of the circuits to be discussed here may be traced completely on this drawing. The discussion will be on only one line circuit of the 230B, but there are four line circuits in parallel. What applies to one line circuit applies to each of the others. The same circuits exist in the 202D KTU, so these descriptions also apply to the 202D. Except for very minor differences, the same symbols and descriptions also apply to the 230A, 232A, and 202C KTUs.

With the 230B KTU it is possible to have either grounded ringing or metallic ringing. However, with this type system the usual policy is to use metallic ringing. Therefore, our discussion here will use metallic ringing. Refer to foldout 1 while reading the rest of this analysis on the 230B and 232B KTUs.

Exercises (608):

Use foldout 1 to answer the following exercises.

1. What type connection is to be noted at terminals 14 and 16 of terminal strip A on the 230B KTU?

2. Identify the devices shown for the dial in the 564HL telephone set.

3. What are the two types of audible signaling connections shown for the 230B KTU?

2-2. 1A1 Key System Operation

We shall first consider the sequence of operation for an incoming call to the telephone set. You should remember that ringing current will activate the lamp and energize an audible signaling device. We shall then examine the circuit effects of a call that is answered, held, or transferred and the response of the equipment when you complete the call.

609. Trace a 1A1 equipment incoming call and name devices and connections that complete a specified operation.

Ringing. Ringing current (20-cycle AC) is applied to the ring side of the line on an incoming call (terminal 8 of the 230B KTU); AC current flows through the normally closed contacts B4 of the AH relay, capacitor R, thermistor R, and the secondary winding of the R relay to the tip side of the line on one half of the cycle. During the other half cycle, current flow is from the tip side of the line (terminal 7) through diode R over the same path as previously described, to the ring side of the line. Contacts B4 of the AH relay and B9 of the A relay together establish a path for current that bypasses the H relay and prevents the establishment of a false hold condition, which might occur when a number of ringers are bridged across the station side of the line. The 317A varistor R1 protects the 400E diode and thermistor R from transient currents.

Thermistor R has a nominal resistance of about 50,000 ohms. This prevents false operation of relay R on disconnects or from transient currents. Ringing current increases the temperature of the thermistor, which reduces the resistance to about 3000 ohms in about 1/2 .

R Relay Operation. The one-half cycle of ringing current operates the R relay closing M4, M6, M8, and M10 contacts.

M4. The closing of contacts M4 places ground on the LK lead, through the secondary winding of the R relay. The LK lead may be traced from contacts 4 to contacts 5 of the AH relay, to terminal 22, to the 232B KTU, terminal 38, through the bimetal contacts 1 and 2 to 20 volts battery. This circuit locks up the R relay under the control of the AH relay, the LK lead and the bimetal contacts of the 232B KTU.

M6. The closing of contacts M6 operates the audible signal. Trace from the stationary contacts of M6, to the left, to terminal 10, out through the audible signal, back to terminal 25, which is strapped to terminal 30 and the ground side of the audible signal power supply. Retrace this circuit back through terminals 30, 25, the audible signal and terminal 10, through the made contacts M6, then to terminal 9 of the 230B KTU and out to option "X." This wiring will go to terminal 21 of the 232B KTU to pins 7 of the interrupter plug, to contacts 2 of the interrupter, to pins 4 of the plug, to terminal 29 and to the "hot" side of the audible signal circuit, under the control of the interrupter at contacts 2.

M8. The closing of contacts M8 of the R relay completes two separate circuits, one through the heater on the TO relay and the other through the windings of the ST relay of the 232B KTU. Trace the first circuit from ground at M8 of the R relay, to terminal 23 of the 230B, out on the TO lead to terminal 36 of the 232B KTU, through the 112-ohm heater resistor, through the closed contacts 3 and 2 of the TO relay, to 20 volts battery. Current flow in this circuit makes the 112-ohm resistor hot. Thus, in a period of about 30 seconds, the bimetal contacts in the TO relay heater open the circuit to release the R relay, if the call has not been answered in the meantime. Now, to trace the second circuit involved by the closing of contacts M8 of the R relay, trace through the same terminals and TO lead to terminal 36 of the 232B KTU, through the strap to terminal 35 and through the windings of the ST relay to 20 volts battery. This operates the ST relay. The results of the operation of the ST relay will be covered in a later paragraph.

M10. The closing of contacts M10 completes the circuit to light the lamps on the telephone. It is recommended that this circuit be traced from the stationary contact of M10, up to contacts EBM2 of the AH relay, over the contacts EMB8 of the A relay, to terminal 15 and 5, out of the L or lamp lead to the telephone, through the lamp, back to the LG or lamp ground lead to terminal 6 and lamp power supply ground. Having found ground, retrace the circuit to contacts M10 of the R relay. From these now closed contacts, trace to terminal 19 of the 230B KTU, out on the LF lead to terminal 1 of the 232B KTU, through the strap to terminal 2, to pins 10

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of the interrupter plug, to contact 4 of the interrupter, to pins 17 of the plug, to terminal 10 of the 232B KTU to the "hot" side of the lamp power supply.

If you will review the circuits we have just traced, you will find that we have the R relay locked up, the audible signal operating and the lamp in the telephone lit, all under control of the 232B KTU. If the call is not answered in the 30 seconds that it takes for the bimetal contacts at the TO relay to operate, the R relay will release and everything will go back to normal.

ST Relay. Now, return to the ST relay. The operation of the ST relay closes contacts 1 and 2 both above and below the relay. They are in parallel and are connected directly to terminal 26 and the "hot" side of the 10 volts, 60-hertz AC of the power supply.

From these now closed contacts, trace to pins 2 of the plug, through the motor (M) to pins 1 of the plug to terminal 27 and the ground side of 10 volts AC. This circuit starts the interrupter motor operating.

Interrupter Operation Results. To show what the operation of the motor does, each set of contacts will be described in detail, from contact 1 down to contact 8. All contacts are shown on the drawing in their starting or normal position.

Contact 1. This operated contact closes approximately 0.25 second after the initial operation of the ST relay. When closed, it completes an operating path for the interrupter motor M. This will operate the motor when the ST relay is released and until it returns to its normal or starting position. In other words, the motor always returns to the point where all contacts are in the position shown in the drawing.

Contact 2. This operated contact furnishes an interrupted signal voltage to the audible signal device(s) connected to the line circuits of the 230B KTU that have the R relay operated.

NOTE: One unusual feature of the audible signal obtained under the control of the interrupter is that the signal does not follow the interruption frequency of the central office ringing signal but is completely independent of the central office after the motor has started.

Contacts 4 and 5. These two sets of contacts control the flashing lamps that indicate an incoming call. They operate at a frequency of approximately 0.5 second on and 0.5 second off and flash the lights connected to the line circuit that has the R relay operated in the 230B KTU. Each contact, 4 and 5, is actually a pair of contacts, each capable of carrying a current of 2.5 amperes. With four contacts, this gives a total lamp load of approximately 10 amperes. This gives enough capacity to care for the entire needs of all lamp circuits in a 6A key system with up to 36 stations. The lamp circuit traced in the preceding paragraphs is connected to contact 4A, so any lamps connected to that particular R relay are now flashing.

Contacts 7 and 8. These contacts control the station lamp wink circuit indicating a hold condition on the line. The frequency of operation is approximately 0.475 second on and approximately 0.025 second off. The contacts are arranged like contacts 4 and 5 with two actual contacts each, rated at about 2.5 amperes per contact.

Exercises (609):

Use foldout 1 for answering the following exercises.

1. Identify the two devices that provide ring circuit continuity between the input and output of the 230B KTU.

2. Identify the telephone circuit device that changes in resistance following the insertion of current in the circuit.

3. Name the contacts that complete the temporary hold circuit for relay R in the 230B KTU.

4. What connecting method is used to provide audible signaling power to a 230B KTU?

5. Identify the 232B KTU circuit device that controls the operating time for relay R in the 230B KTU.

6. Give the 64B1–75 terminal numbers to which the lamp wiring from the 230B KTU attaches.

7. Identify the lamp circuit lead that interconnects the 230B and the 232B KTUs.

8. List the KS–15900 interrupter contacts that complete the flashing lamp circuit to the telephone set.

610. Trace 1A1 key system call being answered to identify action that occur or devices responsible for the actions.

Answering an Incoming Call. To answer an incoming call at a key telephone, the button with the flashing light is depressed and the handset picked up. The immediate noticeable effect is the stopping of the flashing light and the audible signal, and you find that you can answer the call and carry on the conversation. The light under the button is burning steadily now. But in order to know just what has happened in the system, it will be necessary to trace the circuits and operations of the various relays.

A relay operation. A chain of operations is started by the A–A1 or control circuit. The hookswitch of the telephone completes this circuit, which can be traced from terminal 4 of the 230B KTU (which is connected to ground) through the

A1 lead to the telephone, through the hookswitch and back to the KTU on the A lead to terminal 3, then through the coil of the A relay to 20 volts battery. This operates the A relay, which breaks contact B9 and lower contacts EBM11, 8, and 12; it simultaneously makes contact M10 and upper contacts EBM11, 8, and 12.

EBM11. The making of the upper contact of EBM11 makes connection to 20 volts battery and operates the AH relay.

M10. M10 contact is not used under normal conditions.

EBM8. The making of the upper contact of EBM8 connects lamp battery directly from terminal 29 (or 28) to the lamp in the telephone, causing it to burn steadily. At the same time, the breaking of the lower contacts opens the circuit that was flashing the lamp.

B9. The breaking of contact B9 opens the circuit that allowed the ring side of the line to bypass the H relay under power failure conditions.

EBM12. The breaking of the lower contacts EBM12 opens a circuit that would carry the "ring" of the line through the H relay, while the now closed upper contacts again provide a bypass around the H relay.

NOTE: The above operation of the A relay has operated the AH relay, stopped the flashing lights but turned them on steady, and changed the bypass path around the H relay for the "ring" of the line.

AH Relay. The operation of the AH relay opens contact B5, closes contact M1, opens the lower and closes the upper contacts EBM2, and opens the upper contacts EBM2, and opens contact B4.

B5. Breaking contact B5 opens the LK or lock circuit for the R relay. This allows the R relay to release and opens the lamp flashing circuit, opens the TO lead, which stops the heater of the time-out circuit, and releases the ST relay in the 232B KTU, allowing the motor to stop when it returns to its normal position.

M1. Closing of contact M1 operates the TO relay of the 232B KTU. This circuit may be traced from the ground at contact M1 to terminal 24, out on the CO lead to terminal 37 of the 232B, through the coil of the TO relay to 20 volts battery. The operation of the TO relay places another open in the TO lead. As the AH relay is in each line circuit of the system, then whenever there is a line in use in the system, the TO relay will be operated and the heater circuit will be open. This stops all time-out operation when the system is in use.

EBM2. The operation of EBM2 contact opens the lamp flashing circuit and at the same time makes ready a circuit for the lamp wink. As the lamp wink circuit is used only when a line is being held, this circuit will be discussed then.

B4. The opening of the B4 contacts removes the R relay and its operating circuit from the line so there will be no transmission losses through it.

Exercises (610):

Use foldout 1 to answer the following exercises.

1. Tell the results on the signaling circuit when the PICKUP key is depressed and the handset is lifted from the telephone.

2. Identify the relay(s) that operate following depression of a PICKUP key.

3. Identify the relay(s) that release following depression of a PICKUP key.

4. List the 230B KTU terminals that are in the control circuit.

5. What 230B KTU lead completes the power failure circuit?

6. What operated relay completes the "steady" lamp circuit of the telephone?

7. Identify the contacts of the relay of exercise 6 that complete the "steady" lamp circuit.

8. Identify the relay and relay contacts that open the operating circuit for relay ST in the 232B KTU.

611. Identify components or actions of the talking circuit during its operation.

Talking Circuit. With the A and the AH relays operated as described above, there is a direct talking path through the unit, under the control of the A relay, which is in turn controlled by the A and A1 circuit and the telephone hookswitch. This talking circuit may be traced, starting at the top of the incoming line at terminal 7, directly to terminal 1, through the cord and telephone, back on the ring of the cord to terminal 2, through the new closed upper contacts EBM12 of the A relay to terminal 8 and the ring side of the incoming line.

Exercises (611):

Use foldout 1 when answering the following exercises.

1. Identify four telephone set devices that complete the transmission circuit.

2. List devices between the 230B KTU and the 564HL telephone that complete the transmit circuit.

3. Give the operated relay(s) and relay contact(s) that complete the transmit circuit for the 564HL telephone.

612. Given the HOLD condition while tracing 1A1 key system schematic, determine a specific circuit operation or a subsequent result.

If it is desired to hold a line while another line is in use, the HOLD button on the telephone is pressed down. This action will open the A and 1A (control) circuit at the telephone and release the A relay. The handset is still "off hook" so the T & R is still complete. The release of the A relay will allow all its contacts to return to their normal position. The release of contacts EBM12 removes the bypass around the H relay. Current from the central office now passes through the H relay. It now operates.

H relay operation. The operation of the H relay closes its contacts M8, M6, and M4.

M8. The closing of contact M8 completes a circuit from the tip of the line through the coil of the H relay to the ring of the line, through the lower, now closed, contact EBM12 of the A relay. The mechanical release of the line button on the telephone set by the hold button removes the telephone from the line and the H relay is now locked across the line by its own contacts. This puts a 180-ohm resistance short on the line and holds up the central office equipment.

M6. The closing of the M6 contacts picks up the 20-volt battery and through the now closed lower contact EBM11 of the A relay holds the AH relay operated. The AH relay is slow-release and remains operated during the time between the release of the A relay and the operation of the H relay.

M4. The closing of the M4 contact completes a circuit from the ground at M4 to terminal 21, out on the HA lead to terminal 35 of the 232B KTU and then through the coil of the ST relay to battery. This operates the ST relay and starts the interrupter motor.

Lamps. The lamp for the held line now "winks." This is done under the control of the AH relay and the interrupter motor of the 232B KTU through the LW lead and circuit. To trace the LW or lamp wink circuit, start at terminal 6 of the 230B KTU, which is lamp ground (LG), out through the LG lead to the telephone, through the lamp and back to the KTU on the L lead to terminal 5, through the now made lower contacts of EBM8 of the A relay, through operated upper contacts EBM2 of the AH relay, to terminal 20, out on the LW lead to terminal 11 of the 232B KTU to plug pins 12, contact 7B, to pins 14, to terminal 19, to terminal 9 and lamp battery. The winking continues until the line is again picked up.

NOTE: Placing a call is the same as answering except the "R" relay is not operated. Therefore, we will not make an analysis of placing a call.

Exercises (612):

Use foldout 1 when answering the exercises below.

1. Identify two devices released by the depressed HOLD pushbutton.

2. Identify the relay(s) that operate following depression of the telephone HOLD key.

3. List all the operated relays during the hold condition.

4. Give two symptoms to be noted following depression of the HOLD pushbutton.

613. For the power failure condition, identify a result to be noted, a likely symptom, and a connection that exists from the condition.

Power Failure Circuits. Operation of a telephone in the system for outgoing calls during a period of power failure at the user's location will seemingly be normal except that there will be no lights on the telephone. This circuit may be traced, with the circuit in its normal, unoperated condition, as it is drawn. Trace from terminal 7 of the 230B KTU, through the KTU of the telephone and back to terminal 2 of the KTU, through the normally closed contacts B9 of the A relay and B4 of the AH relay, and to the ring side of the line. During power failure conditions, no incoming calls will be received unless a ringer has been bridged on the line.

Exercises (613):

Use foldout 1 when doing the following exercises.

1. State one trouble symptom to be noted during power failure.

2. What is the normal key system response to be expected during a power failure?

3. What 230B KTU connection provides the situation in exercise 2?

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614. Trace a typical dial selective intercom unit and identify circuit terminations, components, operations, or results from specified procedures.

Dial Selective Intercom Unit. The 207C KTU is a nine-station dial selective intercommunication unit. It will select and signal any one of nine stations by means of a step switch, controlled by the dial at the telephone. It has but one talking circuit that is common to all stations; therefore, only one conversation is possible at one time. The 207C is completely independent in operation from any other unit in the 1A1 key system. (In later Bell System Practices, the 207C is frequently referred to as "Selector only, 6A equipment." Here we are including it as a part of the 1A1 key system, but it should be thought of as a completely independent part of that system.)

The circuits of the 207C KTU are shown in foldout 2. In our discussion here, we use only that part of the complete circuitry that is needed for the nine-station system. In the following paragraphs we explain in detail how the circuits and relays operate. Follow the circuits through the schematic as you read; take your time and become completely familiar with the circuit and its operation.

NOTE: Remember, there is only one talk circuit and all telephones are connected across ring and tip as on a party line. Ring and tip connections are shown at terminals 1B and 2B.

All battery and other power must be brought to the unit, either by strapping it from other KTUs in the system or direct from the power unit. On the schematic shown in foldout 2 the DC voltages necessary are shown connected to terminals at the lower left-hand side of the drawing. Talk or "A" battery is connected to 9B and "A" ground to terminal 10B. Signal or "B" battery is connected to terminal 19B and "B" ground to terminal 20B. All grounds are to be strapped together at the powerplant.

Lamp ground and ringer or buzzer supply ground are shown connected to terminals 30B and 40B, respectively, on the right-hand side of the drawing. Lamp power is shown connected to terminal 29B and ringing power to 39B, both on the left-hand side of the drawing. Lamp supply is usually 10-volt, 60-cycle AC. Ringing power could be 18 volts AC for buzzers or 105 volts AC for regular bells. We will assume that regular bells are to be used.

In the previous KTUs that we have discussed, each relay operated more or less independently of the others. In the 207C KTU there is much more interdependence because no relay is able to do very much by itself. It requires all of them working together to do the job.

We are going to assume that it is desired to place a call to station 9 from some other station. To seize the line, you depress the INTERCOM pushbutton and lift the handset to close the hookswitch and complete the ring and tip circuit of the telephone. Battery will be present, so sidetone will be heard. (There is no dial tone.) The circuit completed by lifting the handset may be traced, starting from A battery at terminal 9B, through one winding of the A relay, to terminal 2B, out on the ring of the line, through the telephone, back on the tip of the line to terminal 1B, to the other winding of the A relay, and through that winding to ground at terminal 10B. Current flowing through the two windings of the A relay operates it to close its contact M6, and at the same time opens contact B10. The closing of contact M6 places a ground on a lead that goes directly to the windings of the B relay and to battery and operates the B relay. This same ground is also carried on a parallel circuit through the 47-ohm resistor to the A2 capacitor (25MF) of the KS-16171 network. This will equalize the charge on this capacitor as the other plate is connected to battery. The ground plate is charged positive and the battery plate is charged negative; thus the two charges are equal to prevent any further action at this time.

B relay. The B relay will operate all of the contacts shown above the relay, closing the ones shown open and opening the ones shown closed. Each contact will be covered if it serves a purpose.

- Contact M2. This contact makes ready a circuit to furnish ringing power through the selector to ring the telephone selected.
- Contact M4. This contact makes ready a circuit to release the step switch.
- Contact M1. This contact completes the circuit to light the busy lamp on the telephone.
- Contact EMB8. This makes ready a circuit to feed the pulses from the A relay to the selector when the dial is operated; also it makes ready a circuit that operates the C relay on the first of these dial pulses. Digit 1 is not used; only 2 through 0 may be selected.

Assume, now, that the unit is seized and that the lamp at all stations is lighted. The next step in placing a call is to dial the digit assigned to the telephone we wish to call. Since we are attempting to call station number 9, we dial the digit 9. The pulse springs of the telephone dial open the telephone circuit nine times during the operation of the dial. The A relay of the 207C follows those pulses and releases and reoperates nine times. With the first dial pulse, the A relay releases to open contact M6 and close contact B10.

The removal of the ground at contact M6 of the A relay opens the operating circuit of the B relay. This could release the B relay, but capacitor A2 of the KS-16171 network prevents it if the network is in a balanced condition and it is as long as the ground is connected at contact M6. With the opening of contact M6, this is no longer true. The capacitor is now connected so that the side that was positive is now connected through the windings of the B relay to negative battery. Therefore, the plate that was positively charged will become negative. This discharge of the capacitor causes enough current to flow through the 47-ohm resistor and the B relay windings to hold it operated during the period of time that its operating circuit is opened by the release of the A relay. This slow release of the B relay keeps all of the circuits controlled by the B relay in the condition described under operation of the B relay. The closing of contact B10 of the A relay completes a circuit from the ground at B10 of the A relay through the closed upper contacts EMB8 of the B relay and up to the rotary magnet to step the selector one time. At the same time a parallel circuit from contact EMB8 of the B relay operates the C relay.

C relay. Contact M6 closes a completely local circuit which places the C relay on slow to release. When the C relay operating circuit is broken by the action of the A relay, an inductive kick from the primary winding of the C relay induces a voltage into the secondary winding, completed through contact M6, which provides enough current to hold the C relay operated during the dial pulse.

Contact M4 completes a circuit to operate the T relay.

Contact B5 opens the circuit supplying 105 volts ringing current for the ringing of the called telephone. Opening the circuit at this time prevents false ringing.

Contact B9 opens the circuit to release the step switch.

NOTE: The only actual complete operation that took place with the operation of the C relay was the operation of the T relay. But the C relay did take over control of the ringing circuit and of the step switch release circuit.

T relay. The operation of the T relay operates all of its contacts as shown above it. Only the following are of any interest to us: the others are not even wired.

(1) Contact M1. The closing of this contact completes a circuit that at this time is parallel with the operating circuit of the T relay. This circuit charges capacitor A1 of the KS–16171 network and will later make the T relay very slow to release.

(2) Contact M2. This contact prepares the ringing circuit for the called telephone, a circuit that is now held open by contact B5 of the C relay.

(3) Contact EMB6. This contact places the release of the step switch under the final control of the T relay. This circuit is also held open by the C relay, but the T relay will release much slower than the C and so will have final control of the circuit.

ON (OFF-NORMAL) switch. This switch, shown at the top right-hand side of the drawing, is mechanically operated and is held open by a pawl on the end of the step switch lever. as soon as the step switch moves from its normal position, the ON switch operates and closes its contacts 1 and 2, and 3 and 4, and opens contacts 4 and 5. This switch remains in this position until the step switch again returns to its normal, at rest, position.

The other eight pulses of the dial (we are dialing station 9) also cause the A relay to release and reoperate in step with the dial. Each release of the A relay places a ground on the lead that operates the rotary magnet. The operated rotary magnet steps the step switch one step. At the completion of the nine pulses, the step switch will be on contact 9 and the A relay will again operate. This action reenergizes the B relay, which was held operated by its own slow-to-release circuit, and holds it operated during the rest of the time that the telephone is on the line. The A relay, being operated, opens contact B10 to remove the ground that operated the C relay. The C relay will release after a slight delay. The release of the C relay opens its contact M4 and closes contacts B5, B7, and B9. Contact B5 completes a circuit for 105 VAC ringing current from terminal 39B, through contacts M2 of the B relay, through the B5 of the C relay, through M2 of the T relay, to the contacts of the step switch to contact 9 and terminal 19A, out through the R lead to the telephone bell, and back from the bell to ring ground at terminal 36B, 37B, 38B, or 40B. This completed circuit rings the bell at the telephone as long as the step switch stays on contact 9 and the T relay stays operated.

When the C relay releases to open contact M4, the operating circuit for the T relay is open. With this contact open, capacitor A21 of the KS–16171 network is now connected directly across the windings of the T relay, through the 47-ohm resistor and contact M1 of the T relay. This capacitor has a capacitance of 600 MFD and is fully charged. It now begins to discharge through the 47-ohm resistor and the windings of the T relay to keep the relay operated for about 1½ seconds, during which time the telephone will ring at the station called. When the A1 capacitor can no longer hold the T relay operated, the relay releases to stop the ringing.

When the T relay releases at the end of the 1½- second time-delay period, it opens contacts M1, M2, and M4 and closes contact EMB6.

- Contact M1 opens the time-delay circuit for the T relay.
- Contact M2 opens the circuit that was supplying ringing current to the telephone.
- Contact EMB6 closes to complete a circuit for the operation of the release magnet.

To trace this circuit, start at the ground on the contacts of the A relay, through the now closed contact M6 to contact M4 of the B relay, now closed, through contact B9 of the C relay, also closed, through contact EMB6 of the T relay, which has just closed, to contacts 1 and 2 of the ON switch, held closed by the step switch, and to the release magnet, to battery. This circuit operates the release magnet and releases the step switch, which, being spring loaded, returns to its normal position. The step switch, in returning to its normal position, opens the ON switch. Thus the release magnet circuit is opened. (NOTE: The telephone has been rung one time, for a period of about 1½ seconds. If the party does not answer, it will be necessary to redial the number to ring the bell again.)

Only the A and B relays are now operated. They will continue to be operated until both parties hang up at the end of the conversation.

Exercises (614):

Trace foldout 2 to answer the following exercises.

1. Identify the terminating points on the 207C KTU for the key telephone and the A relay.

2. What is the negative B battery potential for the 207C?

3. Tell the two 207C terminals to test for ringing voltage for a bell and the potential to expect.

4. Describe the procedure that seizes the 207C dial selective intercom unit.

5. Name the 207C unit relays that operate at time of equipment seizure.

6. Identify the slow-to-release relays of the 207C unit.

7. Compare the slow-to-release features of the relays listed in exercise 6.

8. Identify the digits to assign to the stations when installing a 9 station selective intercom unit.

9. Name the open contact that starts the slow release of relay B.

10. What device operates to physically step the selector switch in the 207C KTU?

11. Describe the direct action that operates the T relay of the 207C KTU.

12. Identify the action that operates the ON switch of the 207C KTU.

13. Tell the status of the B, C, and T relays when the ringing current circuit is complete in the 207C KTU.

14. Tell the subsequent action to take if the called party doesn't answer the first ring signal.

2-3. 1A2 Key System Operation

We saw that the 1A1 key system provided signaling, holding, supervision, and talking features for an organization. The 1A2 key system also provides all these features. However, the circuits consist of devices that differ greatly from those used with the 1A1. Therefore, we think it important that we describe some of the circuit tracing variations.

615. Identify typical components and a condition of specified devices of the 1A2 key system.

1A2 Key System Components. Since the 1A2 system is transistorized, we have included operational sketches along with the circuit description. As you read the circuit description, you will find figures 2-1 through 2-14 helpful in understanding the individual circuits. You should locate the circuits on figure 2-1, which is a complete schematic drawing of the 400D KTU, the most commonly used CO line unit. We will begin our explanation by analyzing the circuit while idle. In the idle circuit condition, all relays are in the unoperated state, and transistors Q2 and Q3 are off. Q1 is on. All transistors are of the NPN type. Since the 400D is the most commonly used CO line unit, we discuss its circuitry in detail. Refer to the operational sketches and figure 2-1 as you read the circuit description.

Transistor Q1 is held on by positive current supplied to its base through the resistor network formed by RT1, RT2, R4, R8, R16, R11, and the B and C relay coils. Figure 2-2 shows this bias circuit.

Exercises (615):

1. Identify the 400D KTU terminals to which the telephone connects.

2. Give the negative potential required for operating the transistors of the 400D KTU.

3. What is the normal status of the 400D KTU transistors when the 1A2 key system is not in use?

616. Trace 1A2 400D KTU circuits during incoming signal and determine actions of components, results of specified actions, or probable conditions or connections.

Signaling Circuit. Ringing voltage is usually applied across the line with the tip side of the line grounded. (The actual circuit operation will be the same if the ringing voltage is applied across the line with the ring side of the line grounded.) Ringing current flows through the series connected primary and secondary of the L relay, resistor R2, and capacitor C3, which operates the L relay on each half-cycle of ringing current. Figure 2-3 shows this circuit. Ringing current also flows through C2 and R18 (C5 and R17 if the ring side of the line is grounded) to terminal 2 of zener diode CR8.

The negative (−) side of capacitor CT is normally maintained at about −16 volts. Negative half-cycles of ringing current cause CR8 to conduct in the forward or normal direction so that terminal 2 of CR6 is at about −24.5 volts and the − (negative) side of CT charges toward −24 volts. Figure 2-4 shows this operation.

The positive half-cycles of ringing current break down CR8 to keep terminal 2 of CR6 at about 0 volts since the − (negative) side of CT is somewhere between −16 and −18 volts, CR6 is reverse biased to prevent CT from charging. CT discharges through the resistor network formed by RT1, RT2, R8, R11, R16, and the B and C relay coils. The charge

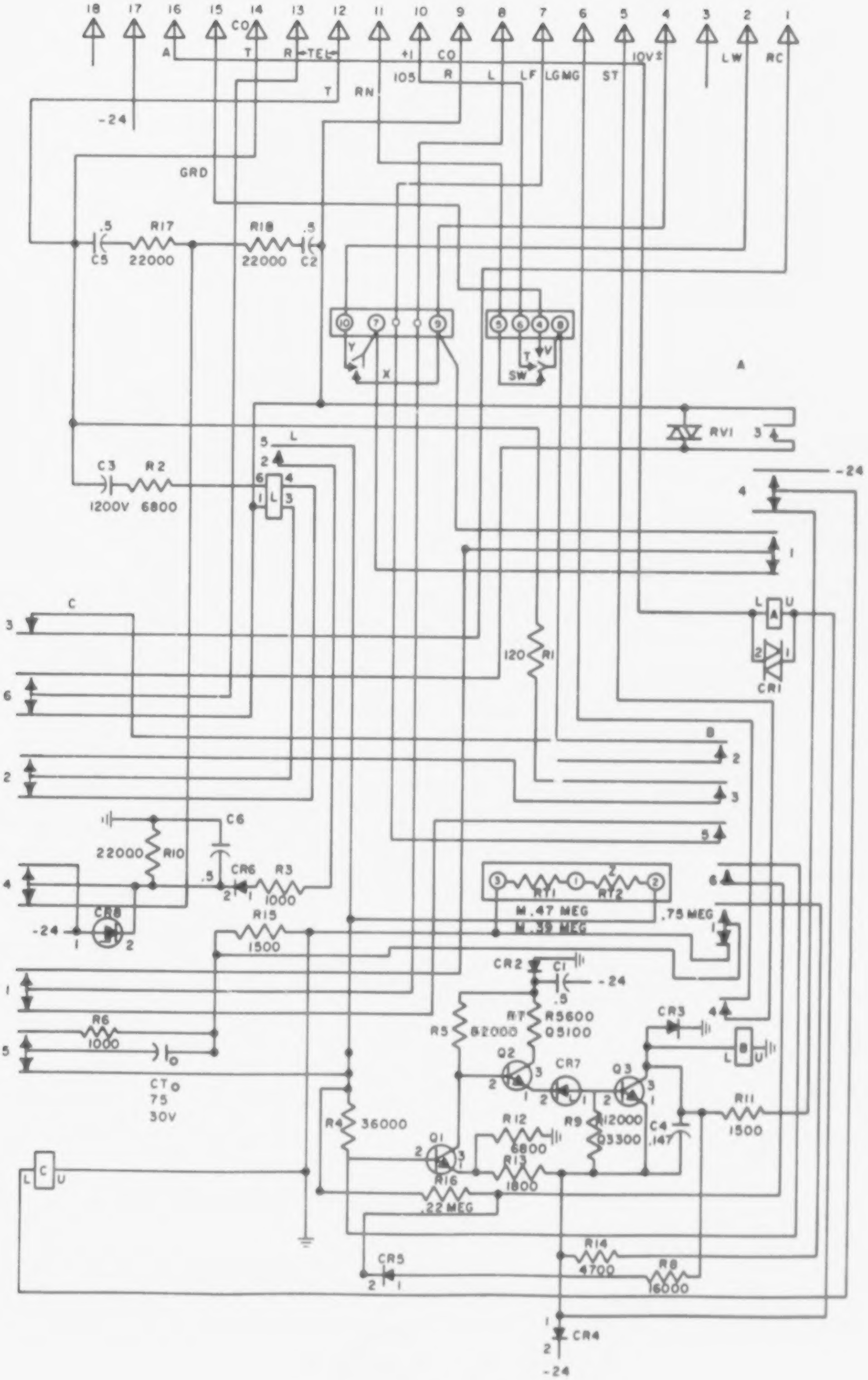

18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
A
CO
T
R
TEL
+1
CO
105
R
L
LF
LGMG
ST
10V±
LW
RC
T
RN
-24
GRD
.5
C5
R17
22000
R18
22000
.5
C2
10
7
9
Y
X
5
6
4
8
T
V
SW
A
RV1
3
-24
4
1
C3
R2
1200V
6800
5
L
2
6
4
1
L
3
L
A
U
2
1
CR1
120
R1
C
3
6
2
B
2
3
5
C6
22000
R10
.5
CR6
R3
1000
2
1
4
-24
CR8
1
2
R15
1500
3
RT1
1
RT2
2
2
M .47 MEG
M .39 MEG
.75 MEG
6
1
CR2
C1
-24
.5
R7
R5600
Q5100
R5
62000
1
R6
1000
5
CT
75
30V
4
CR3
L
B
U
Q2
2
3
1
CR7
2
1
Q3
2
3
1
R4
36000
R12
6800
R9
R12000
Q3300
C4
.147
R11
1500
Q1
2
3
1
R13
1800
R16
.22 MEG
L
C
U
CR5
2
1
R14
4700
R8
16000
1
CR4
2
-24

Figure 2-1. 400D KTU.

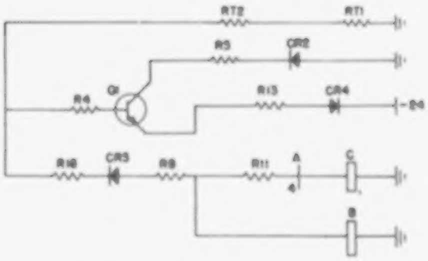

RT2
RT1
R5
CR2
R4
Q1
R13
CR4
-24
R16
CR5
R8
R11
A
4
C
B

Figure 2–2. Positive bias for Q1 (ON condition).

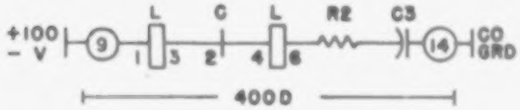

+100
- V
9
L
1
3
C
2
L
4
6
R2
C3
14
CO
GRD
400D

Figure 2–3. L relay operating circuit.

lost by CT during this positive half-cycle is much less than that gained during the negative half-cycle. These discharge paths are shown in figure 2-5.

Since the charge lost by CT is much less during the positive half-cycle than the charge built up during the negative half-cycle, the charge on the − side of CT will gradually build up on the ringing current. After about 1/2 second, a sufficient number of cycles of ringing will have been received to charge CT to about −18 volts. This is equal, but opposite to, the base voltage applied to Q1 transistor, and it will stop conducting. When Q1 stops conducting, its collector voltage rises, raising the positive voltage applied to the base of Q2 and Q2 starts conducting. With Q2 conducting, Zener diode CR7 breaks down and Q3 starts conducting, operating the B relay. Figure 2-6 shows the operation of the B relay. Find these circuits in figure 2-1. (NOTE: Relay C does not operate at this time since resistor R11 limits the current through its winding to less than its operate value.)

Operated relay B connects ground to the ST lead, the L lead, to the LF lead, and the interrupted (option W) or steady (option T) ringing current, or ground (option V) to the RC lead for audible signal control. Transistor Q1 remains off and Q2 and Q3 remain on until the call is answered or timed out. Now, review the sequence in figure 2-7.

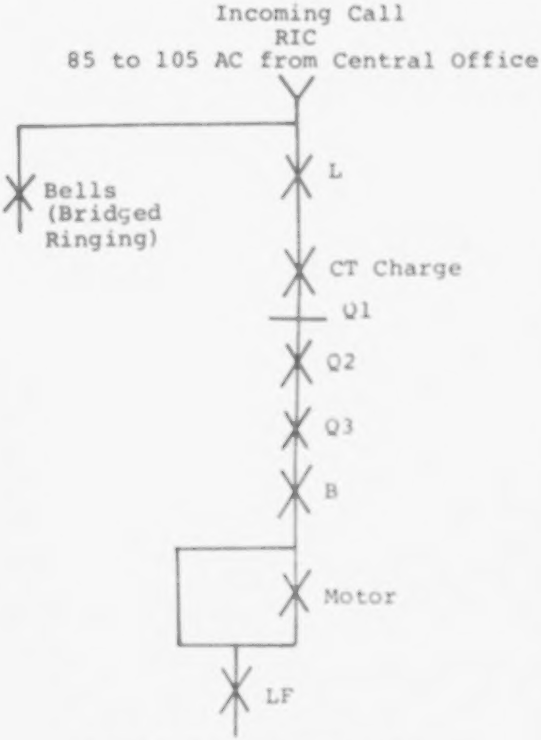

Incoming Call
RIC
85 to 105 AC from Central Office
Bells
(Bridged
Ringing)
L
CT Charge
Q1
Q2
Q3
B
Motor
LF

Figure 2–7. Incoming call sequence diagram.

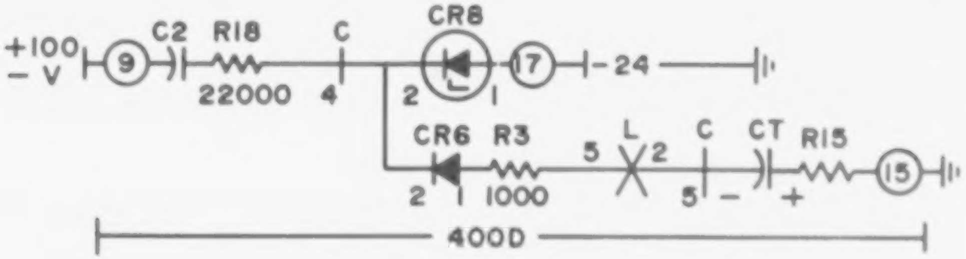

+100
- V
9
C2
R18
22000
C
4
CR8
2
1
17
-24
CR6
2
1
R3
1000
5
L
2
C
5
−
CT
+
R15
15
400D

Figure 2–4. CT charging circuit.

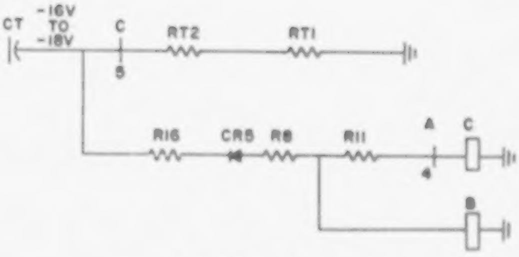

CT
-16V
TO
-18V
C
5
RT2
RT1
R16
CR5
R8
R11
A
4
C
B

Figure 2–5. CT discharge circuit.

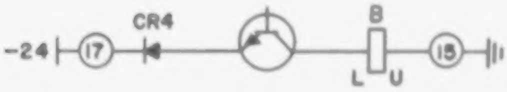

-24
17
CR4
B
L
U
15

Figure 2–6. B relay operating circuit.

Exercises (616):

1. Identify the C relay *made* contacts that complete the L relay operating circuit during application of ringing current.

2. Name the circuit completed by the operated L relay.

3. What is the 400D KTU transistor status when ringing current comes into the circuit from the central office?

4. Which transistor's operating circuit includes the winding of relay B of the 400D KTU?

617. Tracing the 400D KTU and given the "time-out" condition, determine devices or connections that operate or result from specified actions.

Time-Out. At the instant Q1 turns off, the voltage at the − side of CT is about −18 volts. When the B relay operates, the voltage divider formed by resistors R14 and R15 is switched into the circuit, and the voltage at the − side of CT drops from 0 volts to about −6 volts. Consequently, the − side of CT drops from −18 to about −24 volts.

On subsequent positive half-cycles of ringing, CR6 will be reverse biased as before. Operation of relay B connects terminal 1 of CR5 to −24 volts through resistor R8, transistor Q3, and diode CR4. Terminal 2 of CR5 is connected to the base of Q1, which is at about −24 volts, so CR5 does not conduct.

The discharge path for CT is thus only through resistors RT1 and RT2 to ground. On negative half-cycles of ringing, CR6 will conduct slightly to restore the charge lost by CT during the previous positive half-cycle. In this way, the charge on CT, which determines the duration of the time-out, remains constant once the circuit has operated, regardless of the duration of the ringing burst.

When the first burst of ringing has ceased, the − side of CT begins to charge toward ground through RT1 and RT2. Transistor Q1 remains off until the voltage at the − end of CT reaches −18 volts, at which time Q1 turns on and its collector voltage drops. This turns off Q2, CR7, and Q3 and releases relay B. Thus, the circuit is returned to normal. The time required for the B relay to release after a burst of ringing or after a call has been abandoned is approximately 30 seconds.

The time-out of Ringup Circuit (Z Option) arrangement functions in a manner similar to that described above with the exception that RT2 is short circuited. This lowers the resistance through which capacitor CT discharges and results in a shorter time-out.

On incoming calls where one burst of ringing is received, as with manual ringing from a PBX board, the time-out is approximately 11 seconds. Subsequent bursts of ringing received before the B relay releases will reset the time-out circuit to approximately 10 seconds. Incoming calls, signaled by machine ringing, will time out in approximately 10 seconds after the call is abandoned by the calling party.

Exercises (617):

1. State the operated B relay contacts that complete the voltage divider (R14 and R15) circuit between the −24 volt source and ground.

2. Identify those time-out circuit devices of the 400D KTU that
   a. Charge and discharge to control the delay time.

   b. Limit the circuit current to delay the time-out feature.

618. Given the 400D KTU and the ANSWER condition, determine connections, components, or resulting actions.

Incoming Call Answer. An incoming call is answered by operating the PICKUP key with the flashing light and picking up the handset. The station is then connected across the line through the hookswitch and key contacts and ringing is tripped at the central office. Ground connected to the A lead through the hookswitch and key contacts operates the A relay.

(1) The operated relay A makes the following circuit changes:

- Contact 3 makes to shunt the 1–3 winding of the L relay and prevent it from operating on line current.
- Connects −24 volts to the winding of the C relay to operate it (contact 4).

(2) The operated relay C:

- Disconnects the − end of CT from the base circuit of Q1 and connects resistor R6 across CT to discharge it (contact 5). Transistor Q1 turns on immediately to turn off Q2 and Q3 and release relay B.
- Removes the center tap of the ringup bridge from the rest of the circuit, thereby preventing the introduction of noise into the talking circuit (contact 4).
- Disconnects the secondary of the L relay (contact 6).
- Opens the RC lead to discontinue ringing (contact 3).

(3) Relays A and C together:

- Establish the talking path from the telephone to the central office through the KTU circuit, and connect 10-volt AC to the light in the telephone for a steady busy light. Review the sequence in figure 2-8.

NOTE: The procedure for making an outgoing call is the same as that for answering a call except that transistors Q2 and Q3 are normally off and relay B is released.

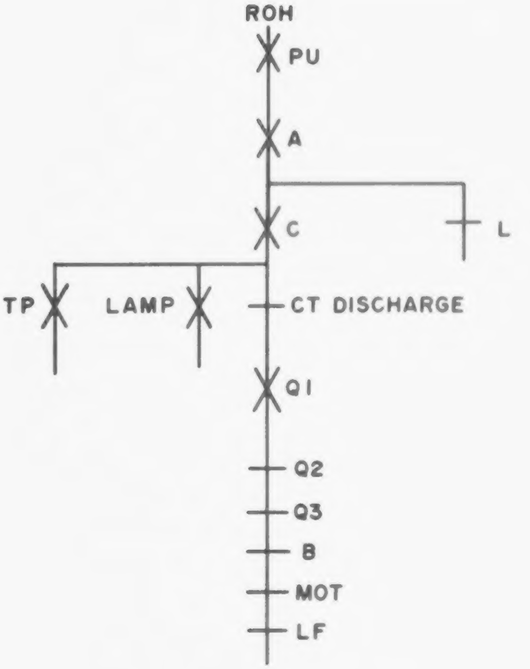


Figure 2-8. Call answer sequence diagram.

Exercises (618):

1. What relay operates to complete the operating circuit of relay C?

2. Identify the resistor and operated relay contacts that parallel time-out circuit capacitor CT.

3. Trace the RC lead circuit and name the four terminals of the circuit (T option).

619. Analyze the 400D KTU circuit to select connections, components, or actions that actuate during the HOLD condition.

HOLD Key Operation. A busy line is held by operating the HOLD key on the telephone. When the HOLD key is depressed, ground is disconnected from the A relay to release it. The A relay contact, which is shunting the L relay primary, opens; and since the station has not yet disconnected from the line, and L relay operates on line current. Figure 2-9 shows a sketch of the L relay holding circuit.

Operation of the L relay connects the base circuit of Q1 through resistor R3, diode CR6, and the operated C relay contact to −24 volts. The voltage at terminal 2 of the L relay contact drops to nearly −24 volts. This turns off Q1 and operates Q2 and Q3. Figure 2-10 shows the circuit for the negative bias that turns off Q1.

Q3 turns on about 3 milliseconds after relay A releases, and provides a hold path for relay C through R11, Q3, and CR4 to −24 volts. See figure 2-11 for a sketch of this circuit. Operated Q3 also provides an operate path for relay B.

The operated relays B and C connect the hold resistor R1 in series with the primary of the L relay across the line. This connection provides the loop to hold the central office equipment. See figure 2-12 for a sketch of this circuit in the KTU; then analyze the sequence chart in figure 2-13. In addition, the B and C relays connect the LG lead to the ST lead, and connect the L lead to the LW lead (Y option) or to 10VAC (X option). When the HOLD key is released, the station is disconnected from the line. Line current through the L relay and R1 maintains the circuit in the hold state.

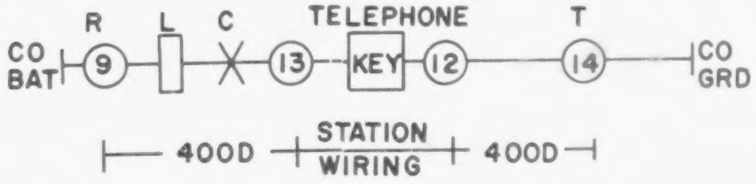


Figure 2-9. L relay holding circuit.

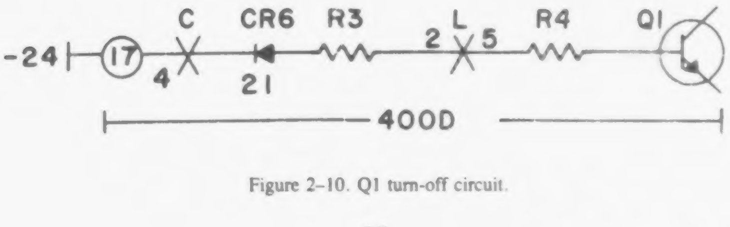


Figure 2-10. Q1 turn-off circuit.

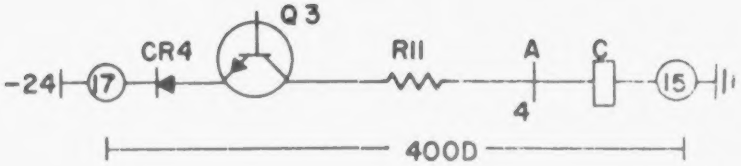


Figure 2–11. C relay holding circuit.

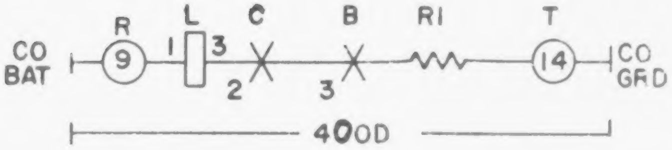


Figure 2–12. Telephone loop for holding CO equipment operated.

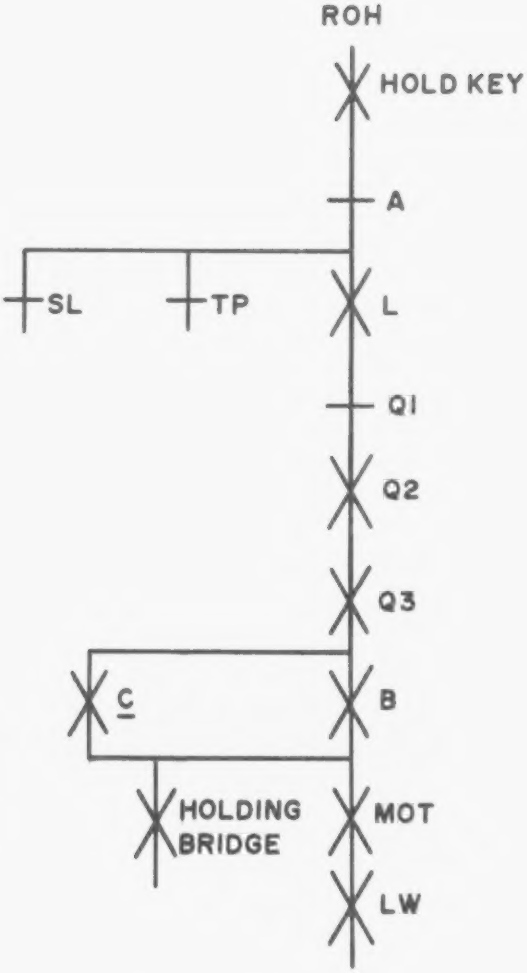


Figure 2–13. Holding sequence.

Exercises (619):

1. Name the relay(s) that operate or remain operated following depression of the HOLD pushbutton.

2. Identify the transistors that operate while the HOLD pushbutton is depressed.

3. Give the 400D KTU terminal number to which the tip of the line loop attaches.

4. Give the 400D KTU terminal number from which the L relay gets its negative potential.

5. Name the 400D KTU terminals that connect together the L and LW leads during the HOLD condition.

620. Interpret the 400D KTU schematic to identify devices responsible for the release of the holding bridge.

Circuit Release. The station attendant of the key system who seized the line and placed it on HOLD again operates the associated PICKUP key. This action operates the A relay and shunts the primary of the L relay, which releases. Transistor Q1 then turns on and Q2 and Q3 turn off to release the B relay. Relay C is held operated by the A relay. The circuit is thus made busy.

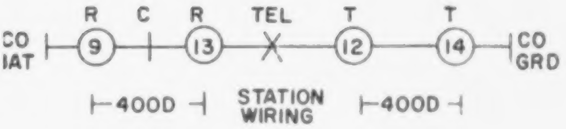


Figure 2–14. Transmit circuit during power failure condition.

When all stations hang up, the A1 lead is disconnected from the A lead to release the A relay. Release of the A relay opens the holding path for the C relay, which in turn releases. Q1 turns on and Q2 and Q3 turn off. The circuit is again in the idle state and ready to accept another call.

Exercise (620):

1. List the 400D KTU devices in the L relay primary shunt circuit.

621. Use the 400D KTU schematic diagram to identify connections in the power failure circuit.

Power Failure Circuit. During periods when the local power supply is inoperative because of power failure, it is still possible to make an outgoing call. When the hookswitch is closed and the PICKUP button is operated, the connection to the line is metallic, as shown in figure 2-14. Both windings of relay L are connected in series with R2 and C3 across the line, but this has a negligible effect on the conversation. No incoming calls will be signaled unless ringers are bridged across the line. Lights and common audible signals will be inoperative. This is the same condition as would exist in any other key system during power failure. At this time, retrace in figure 2-1 the circuit connections described in this section.

Exercise (621):

1. On the schematic (fig. 2-1) identify the attachment point where terminals 12 and 14 interconnect.

2. Identify the C relay normally made contacts that are in the power failure talk circuit.

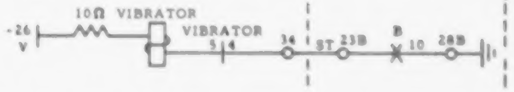


Figure 2–15. Straight line diagram for operating circuit of 224A KTU vibrator.

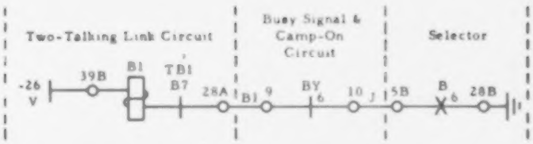


Figure 2–16. Operating circuit diagram-relay B1 in 222A KTU.

2-4. 6A Key Telephone System Operation

We learned that more than one unit has been developed to provide the incoming signal identification function. It is conceivable, then, that more than one device will provide the key system intercommunications. The 6A permits functions that the 207C KTU did not provide. For example, two private talking channels are available, a camp-on feature is provided, and you can make conference calls. Additional services will be noted when we describe the circuits. (NOTE: The 6A does not provide any of the incoming line services furnished by the 1A1 or 1A2 key systems; it is combined with either to provide the intercommunications.)

The 6A key system does compare with the 1A1 key system, however. The similarity is that individual units are assembled and wired at the factory and are combined, as required, to provide the desired features. Yet, units manufactured by one company may not be compatible with units furnished by a second company. Consequently, the normal practice is to order all units for your system from one manufacturer. If you must order a replacement KTU from a second company, make sure that it is identical in size, operation, and connections with the one to be replaced.

622. Trace the given 6A schematic to identify components, units, or connections during seizure.

6A Preliminary Operation. We saw that the intercommunications system enables you to dial a selected station using either one digit or two digits. The same dial selective intercom KTU that we studied earlier is included as a unit of the 6A system. Therefore, we will review its actions while showing additional wiring and its effects on equipment that operates in association with it. To illustrate, by pressing the INTERCOM key and lifting the handset you operate the A relay in the dial selective intercom KTU. Trace foldout 3 to learn the additional devices that make up the operating circuit for the A relay. Although the L relay of the station signaling circuit also operates at this time, it performs only a preparatory function for a future operation. As we noted in section 2-2, of this chapter, the operated relay A completed

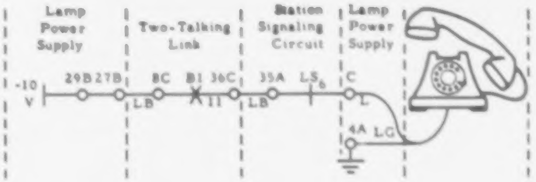


Figure 2–17. Diagram of telephone station lamp circuit.

the operating circuit of relay B. Now, tracing each pair of contacts on the operated B relay discloses additional circuits. Contact M10 completes the circuit for the vibrator, which provides busy/dial tone. Figure 2-15 shows the vibrator circuit. Operated contact M1 of the lamp circuit, which we viewed earlier, and contacts EM12 could provide lamp features; however, they are not functional when using the dial selective intercom unit with a 6A key system. Operated contact EMB6 connects ground to the operating circuit of relay B1 in the two-talking link circuit. Figure 2-16 traces this relay circuit, which is shown in foldout 3. This effort insures that you understand the operating principles of a 6A key system.

The operated B1 relay in the link circuit completes a telephone set lamp circuit, connects ground to the operating circuit of the ST relay in the 232B KTU (providing this unit is furnished), and connects ground to the time-out (TO) relay circuit. Figure 2-17 illustrates a busy lamp circuit. Remember: the operated ST relay starts an interrupter or motor which will interrupt the lamp circuit regularly when you desire a flashing lamp. Also, we have traced the ST and TO relay circuits on foldout 3 because they were available; however, the 10B and 18A punchings (terminals) of the link circuit could be connected to any other unit containing a TO or an ST relay.

The operated vibrator provides dial tone to the telephone set user if this optional feature is desired. Of course, you press the INTERCOM key and lift the telephone handset to get dial tone. Dial tone requires another KTU (227B), which we will not cover.

Exercises (622):

1. Identify the relay A operated contacts that complete the operating circuit for relay B in the 207C KTU.

2. Identify the 207C KTU punchings that connect together following the operation of contacts EM12 on the B relay of the 207C KTU.

3. Name the interconnecting lead between the 207C KTU and the 222A KTU that provides power for the telephone set visual indicator.

623. Trace the 6A schematic and identify connections, components, or results of operations during dialing.

Dialing. While you are dialing, release and reoperation of the A relay occurs as described previously. Refer to foldout 3. Thus, the selector switch steps and relays C and T operate as a result. Additional relays must operate when double digits are dialed. Digit 2 is used for transfer purposes.

Exercises (623):

1. List the circuit components that operate the C relay of the 207C KTU.

2. Tell the circuit conditions in the 207C KTU at the time that the rotary magnet steps the switch wipers.

3. Identify the operated contact that completes the operating circuit for relay T in the 207C KTU.

624. Given the 6A schematic, specify operations, connections, units, or situations during the period between having dialed and the lifting of the called telephone handset.

Circuit Interconnection. Having finished your dialing, you await the indication that the called party has lifted the telephone handset. Yet we know that circuit actions are responsible for this signal. Included in these actions are:

a. In the selector circuit,

(1) The A relay operates again, thus reoperating relay B.

(2) Relay C restores after a delay.

(3) Relay T remains operated temporarily following the release of relay C.

b. In the two-talking link circuit,

(1) Relay BC operates. Its operating circuit is the result of the C relay being released and the T relay remaining operated. Figure 2-18 illustrates the complete circuit. It is evident during your tracing of this circuit on foldout 3 that several optional methods are possible for completing this circuit. For example, ground potential can be connected directly to terminal 39B of the selector circuit, or the potential can be provided under the control of relay LTR in the link circuit and BY in the busy signal and control circuit. We are showing the latter procedure. Regardless of the connecting method, during the slow-to-release period of

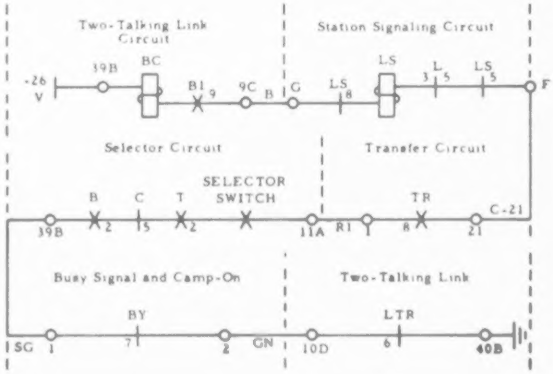


Figure 2-18. Relay BC of 222A KTU operating circuit line diagram.

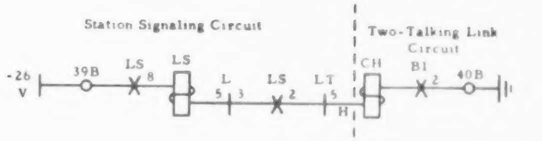

Station Signaling Circuit
Two-Talking Link Circuit
-26 V
39B
LS 8
LS
L 5 3
LS 2
LT 5
H
CH
B1 2
40B

Figure 2-19. Locking circuit for relay LS, station signaling circuit.

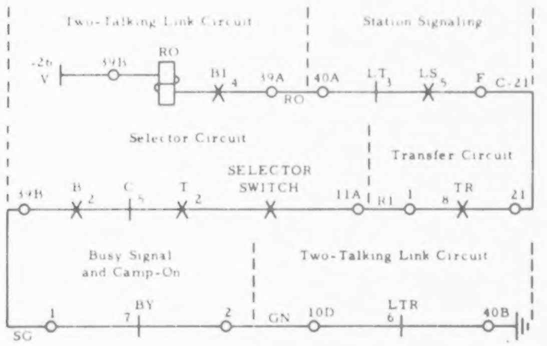

Two-Talking Link Circuit
Station Signaling
-26 V
39B
RO
B1 4
39A
RO
40A
LT 3
LS 5
F
C-21
Selector Circuit
Transfer Circuit
SELECTOR SWITCH
39B
B 2
C 5
T 2
11A
R1
1
TR 8
21
Busy Signal and Camp-On
Two-Talking Link Circuit
SG
1
BY 7
2
GN
10D
LTR 6
40B

Figure 2-20. Diagram showing operating circuit for relay RO, two-talking link circuit.

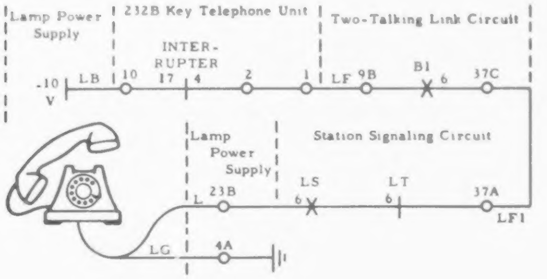

Lamp Power Supply
232B Key Telephone Unit
Two-Talking Link Circuit
INTER-RUPTER
-10 V
LB
10
17 4
2
1
LF 9B
B1 6
37C
Lamp Power Supply
Station Signaling Circuit
L 23B
LS 6
LT 6
37A
LF1
LG
4A

Figure 2-21. Lamp circuit for indicating an unanswered call.

relay T, you must see relay BC operate. Although relay LS of the station signaling circuit is connected in series with relay BC, it has too great a load to operate with the current of this circuit.

(2) Relay BC1 operates. Operated contact M6 of relay BC completes the operating circuit for relay BC1. Operated contacts EMB6 and B7 open a circuit for relay TB1. Operated contact M2 of relay BC1 shunts the 9100-ohm resistance of relay BC, thus increasing the current for relay LS. Consequently the contacts of relay LS for the called station move to the operated position. The released BC relay, in turn, restores relay BC1. Relay LS does not restore, however, because its operated contact EMB8 has completed a locking circuit. Figure 2-19 shows this locking circuit.

(3) Relay RO operates. Operated contact BM5 of relay LS completes the operating circuit for relay RO. Figure 2-20 illustrates the RO relay circuit. This circuit is made possible because of a wiring option referred to as the AL option where terminal 39A of the two-talking link circuit is connected with terminal 40A of the station signaling circuit.

c. In the station signaling circuit,

(1) Relay LS operates. The operating and locking circuits for relay LS have already been described. The CH relay in the LS relay locking circuit has too little current to operate at this time. Operated contact EMB6 of relay LS completes the flashing lamp circuit for the called telephone set. Figure 2-21 illustrates this flashing lamp circuit. We have used terminal 23B rather than terminal C, as shown in foldout 3, because C is a reference designation for the third terminals. Look at the punching chart between figures 2 and 19 on foldout 3, and you will see where this 23B determination was obtained. Parallel to the C reference are 3A, 13A, 23A, etc. For Circuit 7 (station7), 23B is shown as the proper punching to use. Remember: Contact 4 of the interrupter unit is operated at regular intervals when the interrupter is operating. Operated relay ST started it to operating. Operated contacts PMEB4 and PMEB9 of relay LS complete a ringing circuit for the called telephone. Tracing figure 2-22 and foldout 3 discloses

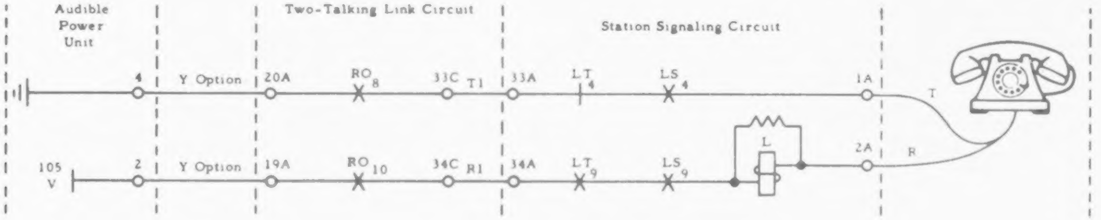

Audible Power Unit
Two-Talking Link Circuit
Station Signaling Circuit
4
Y Option
20A
RO 8
33C
T1
33A
LT 4
LS 4
1A
T
L
2A
R
105 V
2
Y Option
19A
RO 10
34C
R1
34A
LT 9
LS 9

Figure 2-22. Line diagram showing 6A system ringing circuit.

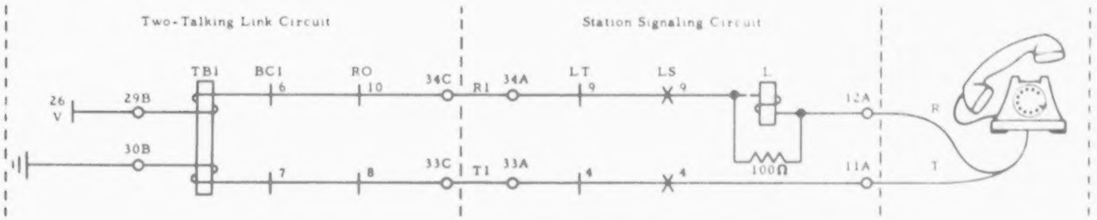

Two-Talking Link Circuit
Station Signaling Circuit
26 V
29B
TB1
BC1 6
RO 10
34C
R1
34A
LT 9
LS 9
L
12A
R
30B
7
8
33C
T1
33A
4
4
100Ω
11A
T

Figure 2-23. Operating circuit for relay TB1, two-talking link circuit.

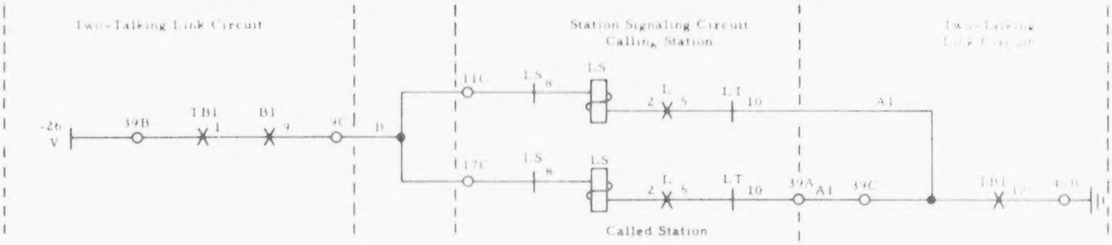

Two-Talking Link Circuit
Station Signaling Circuit
Calling Station
Two-Talking
Link Circuit
-26
V
39B
TB1
1
B1
9
9C
B
11C
LS
8
LS
2
L
5
LT
10
A1
17C
LS
8
LS
2
L
5
LT
10
39A
A1
39C
TB1
4B
Called Station

Figure 2–24. Second operating circuit for relay LS.

that this circuit is made possible by connecting terminal 20A of the two-talking link circuit with terminal 4 (ring ground) at the audible power unit and terminal 19A with the 105V ringing terminal (2) at the audible power unit. Of course, other connecting options are possible, but most of them include contacts of relays RO and LS.

d. In the optional wiring,

(1) AK option. We may choose the AK option to place the RO relay operating circuit under control of the interrupter Thus, the released RO relay breaks the ringer circuit at intervals. This interruption results in a 1-second operate and 3-second release timing cycle. An interrupted signal may be provided to the calling station as a ringback tone. The released T relay in the selector circuit completes the operating circuit for the release magnet.

(2) AL option. Whereby the restored T relay opens the operating circuit of relay RO in the two-talking link circuit. Hence, the selector switch returns to its original position. Relay LS at the called station will not release, although relay L operates following your lifting of the handset because of its slow-to-release characteristics.

If the telephone set is installed with a SIGNAL key in place of one PICKUP key, the operated key operates relay BC of the two-talking link circuit. The operated BC, in turn, completes the BC1 relay's circuit. Your review of the preceding paragraph will disclose again what additional conditions occur after relay BC1 operates. The audible signal at the called station will continue as long as the signal key is pressed.

Exercises (624):

1. Tell the condition of relay LTR in the 222A KTU when the preliminary operating circuit for relay LS is complete.

2. Compare the releasing methods for relays BC and BC1 in the 222 KTU during the preparational period for the call to be answered.

3. Identify the 222A KTU punchings and strapping that provide the operation of relay RO in the two talking link circuit.

4. Use the punching chart and assuming station 5, give the 222A KTU "B" punchings to use for completing the station's lamp circuit.

5. Identify the 222A KTU "B" punchings that are strapped for lamp ground.

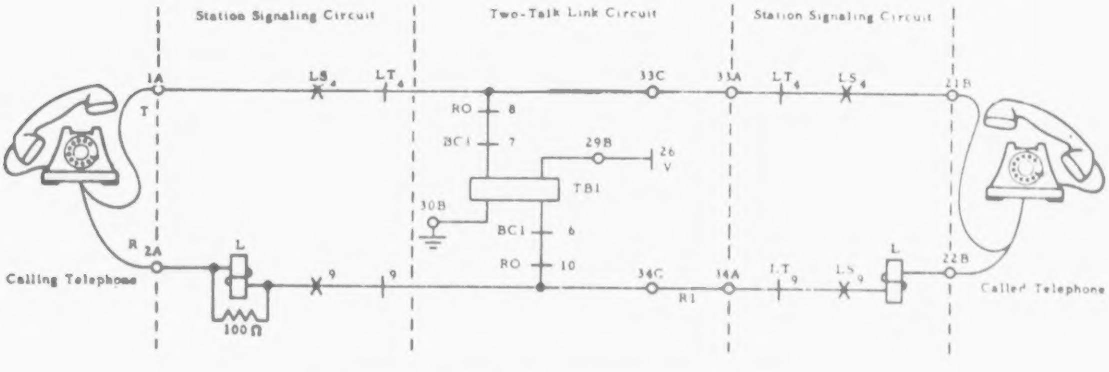

Station Signaling Circuit
Two-Talk Link Circuit
Station Signaling Circuit
1A
T
LS4
LT4
33C
33A
LT4
LS4
21B
RO
8
BC1
7
29B
26
V
TB1
30B
BC1
6
RO
10
R
2A
L
9
9
34C
R1
34A
LT9
LS9
L
22B
100Ω
Calling Telephone
Called Telephone

Figure 2–25. Typical talking circuit in 6A telephone system.

625. From a given schematic specify applicable connections and devices that permit answering a call or typical results when a call is answered.

Answering a Call. Having lifted the handset at the called station in response to the signals, you operated the TB1 relay in the two-talking link circuit. Figure 2-23 illustrates this relay operating circuit. The operated L relay in the circuit opens the preliminary holding circuit for relay LS of the station signaling circuit at the called station; however, operated contacts M1 and M12 of relay TB1 renew the circuit again. At the same time, relay LS at the calling station is operated. Figure 2-24 represents the LS relay circuit. Operated contact B7 of relay TB1 opens the operating circuit of relay B1. Operated contact EBM8 of relay LS again completes the locking circuit for relay LS. This connection is necessary because restored contact M9 of relay B1 removes the preliminary battery connection. Operated contact M4 of relay TB1 provides the power for the lamp circuit of the telephone; thus, it replaces contact M11 of the restored B1 relay. Operated contacts PMEB4 and PMEB9 of relay LS of the calling telephone open the operating circuit of relay A in the selector circuit. Restored relay A opens the operating circuit of relay B. Therefore, the relays that initially processed the call are now released. Figure 2-25 shows the talking circuit between the two telephone sets. You should also be aware, now, that the power for this conversation passes through relay TB1.

Operated contact M6 of relay TB1 completes the operating circuit of relay LTR in the two-talking link circuit. Operated contact M2 of relay LTR completes an operating circuit for the LT relays at both stations. Operated contacts PMEB4 and PMEB9 of relay LT transfer the talking circuit of the telephones from the T1 and R1 leads to the T2 and R2 leads. Consequently, relay TB1 is released while relay TB2 becomes operated. Operated contact M12 of relay TB2 completes the operating circuit of relay H and provides ground which holds relay LS operated. Operated contact M2 of relay H provides the holding ground for relay LT. Contact EBM8 on relay H opens the operating circuit of relay LTR. This switching operation is referred to as "transferring from the primary to the secondary talking link."

(NOTE: You may hear a click during the circuit transfer caused by the battery supply change from relay TB1 to TB2. The result, then, is that two telephone users can have a private conversat while another intercom user can originate and complete a call to a fourth party in the system. The second call would be completed through the operations of relays A, B, C, T, ROT A, RLS A, R1, TR, B1, CH, BC, BC1, RO, and TB1 which are shown on FO 3.

Only those people at the stations which are connected to the primary link at the time of transfer to the secondary are able to converse. No other person can enter the connection This limiting provision is referred to as "automatic cutoff." Again, a wiring option determines whether you provide this isolation or not. We noted that relay B1 was restored. Its release opens the operating circuits for LS relays at the stations which are to be cut off. We also saw that operated contact M1 of relay TB1 provides the battery for the LS relays which are to remain operated at the two stations that will be connected for conversation.

Exercises (625):

1. To what punchings do you connect the direct current source for transmitter power for the 6A system?

2. Identify the transmit circuit relays of the 222A KTU and state the usual manner in which they operate.

3. Tell the 223A and 222A KTU punchings to be connected together in order for the LT relay in the station signaling circuit to be held operated by the M2 contact of relay H in the two-talking link circuit.

4. List relays operated in the 6A system while a call is in progress.

626. Trace a given schematic diagram to identify conditions to be noted during a called station busy situation.

Busy Condition. The desired station could be unavailable because of a conversation already in progress. When this condition exists, the originated call operates the BY relay of the busy signal and camp-on control circuit. Figure 2-26 illustrates an operating circuit for relay BY. Likewise, if you have provided the dial tone option to the system, the attempted call must operate the relay in the ringing and tone control circuit which opens the dial tone circuit. The operated BY relay completes circuits for holding itself operated, flashing the station lamp, and returning busy tone to the calling station. Operated contact M2 of relay BY connects ground to terminal 22 of the busy signal control circuit, and, in turn, this terminal is connected to the circuit having the relay which flashes the lamp. Operated contact M4 of relay BY connects ground to the operating circuit of the vibrator, which provides the busy tone to the calling

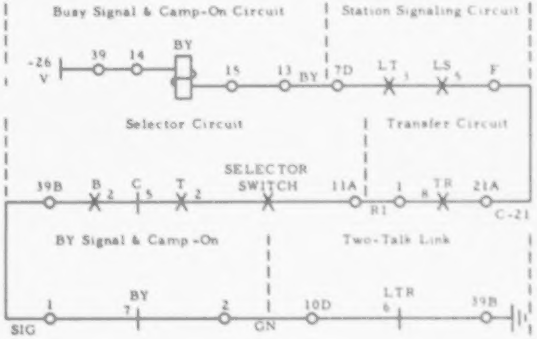


Figure 2-26. Operating circuit for BY relay in 224A KTU.

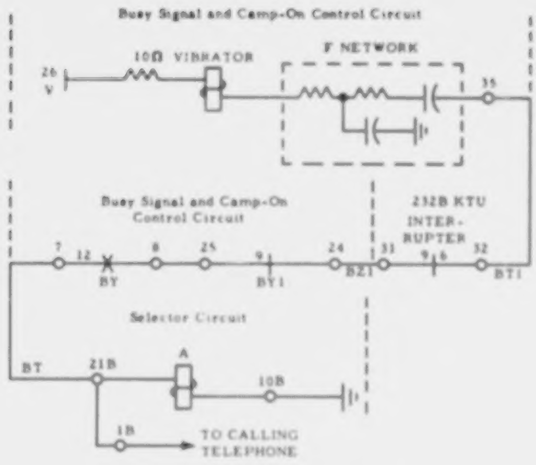


Figure 2-27. 6A key system busy tone circuit.

station. Figure 2-27 depicts the busy tone circuit. Operated contact M1 of relay BY completes a locking circuit for relay T in the selector equipment.

When both talking links are busy, camp-on is provided for some systems. If this feature is available, the calling party dials the code number to select the station. This action reserves the system for your call when the station becomes idle again. The selected station is automatically signaled by the system equipment.

NOTE: This camp-on feature is not possible without using a selector circuit, hence cannot be used with the station using a signal key only. You make your selection although the lamps reflect a busy condition. The selector relay A functions as stated in the preceding description. Also, the dialed code digit activates the selector circuit as formerly shown. The operated OFF-NORMAL switch on the selector provides the connection that operates relay BY1 in the busy signal and camp-on control circuit.

Figure 2-28 illustrates the operating circuit for relay BY1. Remember: In this circumstance where both links are busy, relay BY1 operates before relay BY. Contact BM5 of operated BY1 opens the locking circuit of relay BY, while contacts EBM6, BM7, and PMEB4 open the ground connection of the flashing lamp, vibrator, and relay T circuits. Operated contact BM3 of relay BY1, however, completes the operating circuit of relay BY. Operated contact EBM8 of relay BY opens the operating circuit of relay BY1. Since relay BY1 is slow to release, a period of time will pass before any other actions occur. After the BY1 relay has released, the connections are made which we described earlier. For example, relays T and BY are locked operated and busy tone is connected to the incoming "A" relay circuit. Following the completion of the calls on both links, the BY relay restores because of the open contact M2 at relay B and contact M8 of relay TB1. Contact B7 of released relay TB1 completes the operating circuit of relay B1 in the two-talking link circuit, whereas open contact M1 of relay BY permits relay T of the selector to start its timing cycle toward release. Remember, relay BC in the two-talking link circuit which operated in series with relay LS is shunted when relay BC1 operates, Thus, it releases. The activities that follow this BC relay restoration also were described earlier.

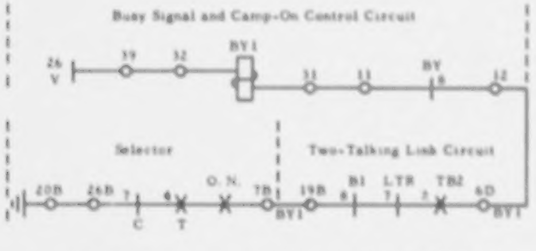


Figure 2-28. Operating circuit for relay BY1 in 224A KTU.

Remember: If the desired station is busy on the secondary link, yet the primary link is free, the same response occurs except BY1 does not operate. Relay B1 controls the circuit that operates relay BY1.

Another 6A system may contain the 224B KTU, which allows the idle station to be signaled when the primary link is released although the secondary link is still busy. The equipment that we have described does not have this provision. Both links must become idle before the desired station can be signaled.

Exercises (626):

1. Tell the two indications to be noted at the 6A system calling telephone when the called station is busy.

2. Identify the operated relay and its associated contacts that provide the indications of exercise 1.

3. State an action required to seize the busy station for a future call.

4. Name the KTU and relay that operates first when both talking links are busy and CAMP ON is requested.

5. What talk link is normally ready for service?

627. Trace 6A key system diagrams and identify probable results, or example connections or actions for a typical preset conference call.

Preset Conference Call. A conversation that includes more than two stations is referred to as a "conference call." When the control equipment and method for providing this type of call are established before the call is originated, the connection is referred to as a "preset conference." Yet, we have learned that it is not normally possible to dial more than one station because the two-talking link circuit isolates the call to two stations on each of the two links. Thus, a method had to be provided where the transfer to the secondary link is delayed until all stations for the conference have answered. This delay is provided by using another 6A system equipment unit. Figure 2-29 is a schematic of a preset conference unit.

You should be aware that pushbutton signaling is possible; however, this provision is not the most desirable because the dial arrangement provides better utilization. We will show that the preset conference unit permits signaling of all conference stations of the system at the same time by dialing a special code digit or by pressing one pushbutton. You know that the operated dial or pushbutton activates relays. Reviewing the selector circuit, we recall that relay C releases before relay T, and that during the time that this condition exists, a ground potential is connected to a C lead of the selector. This grounded circuit includes EMB6 of relay LTR, contact B7 of relay BY, terminal 39B, contact B5 of relay C, and contact M2 of relay T in the selector. The grounded C lead is now connected to terminal 17 of the preset conference circuit. As a result, relay RO1 will operate. Operated contact

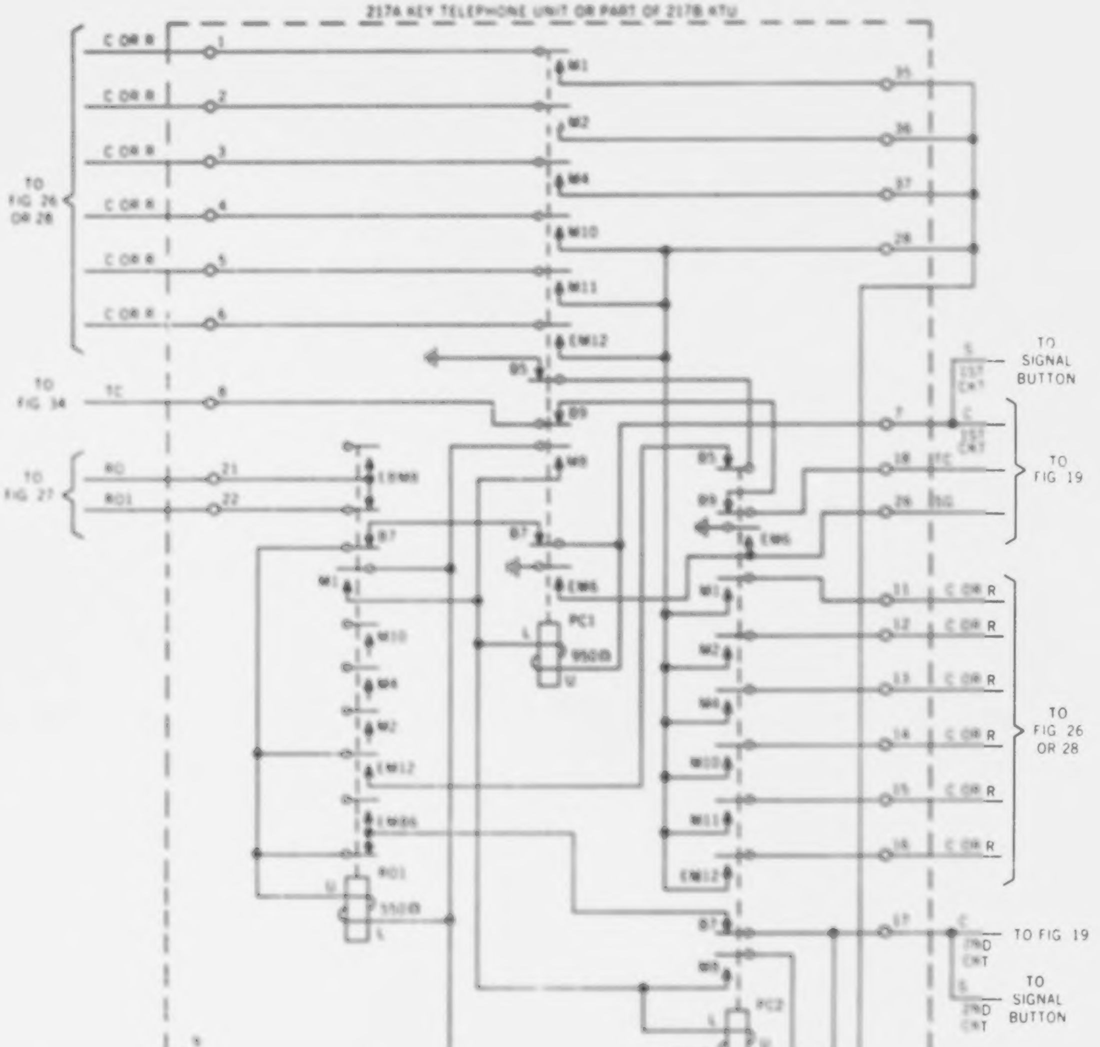

2176 KEY TELEPHONE UNIT OR PART OF 2178 KTU
C OR R
TO FIG 26 OR 28
TO FIG 34
TC
TO FIG 27
RO
RO1
M1
M2
M4
M10
M11
EM12
B5
B9
M0
B7
EM6
EMB6
PC1
PC2
RO1
L
U
950Ω
TO SIGNAL BUTTON
S
1ST CKT
C
TO FIG 19
TC
SG
C OR R
TO FIG 26 OR 28
2ND CKT
TO FIG 19
TO SIGNAL BUTTON
B2
TO FIG 27
1
2
3
4
5
6
8
21
22
35
36
37
28
7
18
26
11
12
13
14
15
16
17
9
10
19
20
23
24
25
27
29
30
31
32
33
38
34

Figure 2-29. Schematic diagram of preset conference circuit.

M1 of relay RO1 completes the operating circuit of relay PC1 or PC2. Figure 2-30 illustrates the operating circuit for relay PC1.

NOTE: If several stations are organized into group 1, they will be connected in a manner that enables relay PC1 to signal them. Using the same method, PC2 operates when the several stations forming group 2 are selected by ground on the C lead connected to the preset conference circuit. Operated contact EMB8 of relay RO1 opens the operating circuit of relay RO in the two-talking link circuit, thereby preventing signaling of any station until all the LS relays for this group of stations have operated. Operated contact EM12 of relay RO1 provides a second operating circuit for relay RO1. It is evident that the ground potential for this additional circuit is connected to contact B5 of relay PC1.

Your analysis of the results from having operated relay PC1 should disclose that 8 of the 11 contacts have made connections. Six contacts complete a connection between ground and the C leads that extend to the LS relays for the six desired stations of the conference. Remember: Relay LS is installed in series with relay BC of the two-talking link circuit and operates only when relay BC1 shunts the winding of relay BC. Operated contact M8 of relay PC1 completes a locking circuit for relay PC1. Operated contact EMB6 connects ground to the SG lead of the unit, which also connects to the selector circuit. This ground will be extended by the contacts of the selector relays to the C lead. Operated contact B5 of relay PC1 opens the locking circuit of relay RO1, whereas operated contact B7 of relay PC1 also removes ground from relay RO1.

The six operated LS relays in the station signaling circuits complete a locking circuit that includes relay CH of the two-talking link circuits. This circuit was shown previously. Also, you learned that operated contact EBM6 of each LS relay completes the lamp circuit for the station. Of course, all lamps are flashing now because the circuit is being interrupted. The released RO1 relay in the preset conference unit closed contact EBM8 and the operated LS relay closed contact BM5; thus relay RO of the two-talking link circuit operates. Consequently, it provides ringing current to the six stations. The ringing provision was described in a previous paragraph.

The released T relay in the selector permits the release magnet to restore the selector switch. As a result, relay PC1 of the preset conference circuit is released. The restored contacts of relay PC1 open the circuits to relays LS and RO. Since the LS relays are locked operated, they are not affected, but relay RO is released. Consequently, the audible signal is silenced.

The first called station to answer operates the TB1 relay. This relay operating procedure follows the same plan already described, except that relay B1 remains operated until all stations have answered the signal. To illustrate, the hookswitch, depressed pushbutton, and telephone network complete a circuit consisting of contacts on relays LS, LT, RO, BC1, and the winding of relay TB1. In addition, operated contact M4 of relay TB1 completes a lamp circuit to the calling station; however, the lamp will flash until all stations have answered because contact EBM6 of relay B1 continues to provide interrupted power. Operated contact M10 of relay TB1 provides the ground that holds relay B1 operated. Each answered station is connected in parallel for the conference; thus, relay TB1 provides the required talking battery. Contact M12 of this latter relay provides the ground that holds the answered stations' LS relays operated.

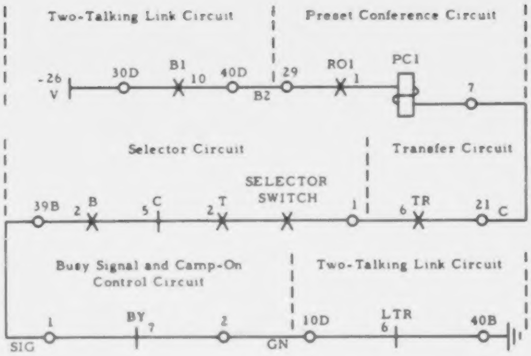


Figure 2-30. Operating circuit of relay PC1 in 217KTU.

When the last station for the conference has answered, the L relay in the signaling circuit operates and removes the final connection for holding the CH relay operated. Consequently, restored contact M6 of relay CH opens the holding circuit of relay B1 and contact B5 of relay CH completes the operating circuit for relay LTR. Now the lamp will burn steadily and the call can be transferred to relay TB2, provided the second link is not busy. We learned that operated relay LTR operates relay LT in the station signaling circuit and relay H. Relays LS and LT, in turn, complete the operating circuit for relay BY when the signaling circuit for the busy station is being held operated. The operated BY relay, then, locks operated, operates the T relay, and causes busy tone to be returned to the station that originated the conference.

Exercises (627):

1. Identify the action that operates the seizure relay (RO1) in the preset conference circuit.

2. List the operated and released relays that operate the RO1 relay in the 217 KTU.

3. Name the two relays and the associated contacts by which ground and battery potentials are connected for the holding circuit of relay RO1 in the 217 KTU.

4. Identify the relays and associated contacts that connect negative and positive battery to the locking circuit of relay PC1 in the preset conference.

5. Tell the relay and associated contacts that connect negative battery to the operating circuit of relay CH in the 222A KTU.

628. Trace the conference time-out circuit diagram to identify components and leads that complete indicated functions.

Conference Time-Out Circuit. An optional feature that is provided by a 217B KTU is conference time-out. Its function is to stop signaling any unanswered station and allow transfer to occur 30 seconds after the calling station originates the call. With this option provided, the subscriber originating the conference operates relay B1, thus closing its contact M3. This action connects ground to lead TD which results in heating the bimetallic contacts of a thermal relay. Figure 2-31 is a portion of a schematic of a 217B showing the time-out circuit using a thermal (TD) relay. Although two sets of contacts for this relay move when the relay operates, contacts 1 and 8 operate before 5 and 7 break. Operated contacts 1 and 8 perform a preparatory action—they connect ground to contacts of and to the winding of relay TDA, thus insuring a rapid response when relay TDA operates. Thus, the operated TD relay also completes an operating circuit of relay TDA with contacts 1 and 8. Operated contact BM5 of relay TDA opens the operating circuit of relay TD; hence, its contacts are permitted to cool. Also, contact BM5 completes the holding circuit for relay TDA. Operated contact M4 of relay TDA connects ground to the CTO lead. It is evident on foldout 3 that the CTO lead is attached to the H lead and the CH relay winding. Grounding this winding results in release of the relay. If you recall the information in a previous paragraph, the release of relay CH began the transfer from the primary link to the secondary link. Regular calls are not affected by the operation of this time-out circuit, because relay CH is functional only during a conference call.

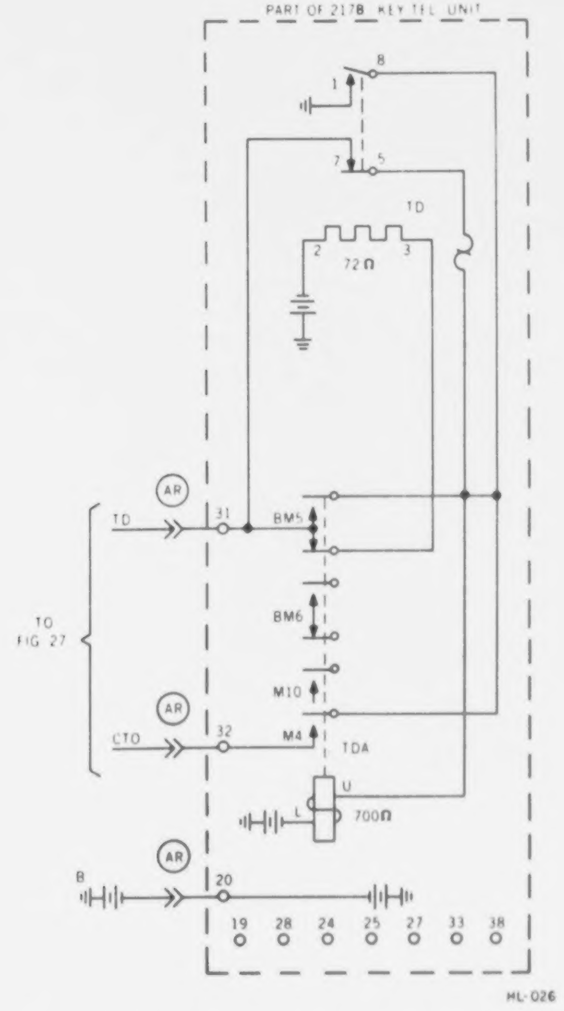


Figure 2-31. Schematic diagram of conference time-out circuit.

Exercises (628):

1. Name the relay in the 222A KTU that must operate to complete the TD relay operating circuit in the 217B KTU.

2. List the devices in the preliminary circuit for relay TD in the 217B KTU.

3. Identify the relay CH shunt lead and tell the relays that must operate to complete the shunt circuit.

629. State two operational differences possible with a 6A key system, and indicate the preferred maximum stations to be installed.

Optional Wiring. We have learned that a key system is flexible because of the optional wiring methods and the operational KTUs for the installation. As a result, you may use different operational procedures for the system. To illustrate, the press conference installation that we described required that you dial a number to originate the call. Also, we revealed that it was possible to have two groups of six telephones connected for conference. If the organization desires that 12 stations be connected for one conference, you could also provide that. In this latter installation, the dialed conference number would operate relays PC1 and PC2 (strapped) simultaneously. We know, too, that a signal button could be used to originate a conference call. Usually, one party would be authorized to originate the conference call; therefore only the depressed pushbutton permits the equipment actions that result in the conference connection. Of course, the operated signal key would then operate relay RO1 in the preset conference circuit, which, in turn, operates the predetermined PC relay.

You may have received the impression that 12 stations are the maximum number that can be installed with the 6A key system. However, this is not true. The recommended number of stations is 18. With this number of stations, two-talk link intercommunication is permitted—or in other words, two conversations are possible at one time. Accordingly, the system is developed to keep the 10-percent trunking requirement of a telephone system. A 6A system can be expanded to 36 stations, but this installation reduces the trunking requirement to less than 10 percent, because only two conversations are yet permitted.

Exercises (629):

1. What are the two methods for activating a conference?

2. Tell two optional arrangements for stations that may be connected for conference.

3. Give the usual installation procedure for connecting a conference function in the 6A system.

4. For effective two-talk link intercommunications, what is the normal maximum number of key telephones in a 6A system?

CHAPTER 3

Installation of Key Telephone Systems

ASSUME THAT you have been asked to put a nut on a bolt. This may appear to be a simple project. However, you must do some planning. For example, you should consider first whether the bolt is to be set within a sink (cavity); if not, it may require a regular washer. Secondly, you probably need to consider if the nut should follow a lockwasher. The project may not be easy, either, because the unit may have to be installed where movement is restricted and where you are unable to see your work. Thus, you may have to use special tools.

To insure that a key system will give the desired service, you must do some preinstallation planning. As a result, installation time and costs are reduced. Similarly, a well-planned orderly installation will require few later changes and little maintenance. Things to consider during planning of the installation include:

a. Operating services and facilities that are to be provided by the system.

b. Specific equipment necessary for providing these services and facilities. Equipment must be sometimes reserved before you order it to insure its availability when needed.

c. Equipment and cable location at the installation site.

d. Provisions for expansion.

e. Local regulations and conditions.

f. A building for housing the equipment.

This chapter contains information about installation planning, selection of key equipment and telephones, placement of the equipment apparatus, and installation of the cables.

3-1. Key System Installation Planning

If there is to be a minimum of interruptions during the installation, there must be understanding and agreement between supervisors who have control of the facilities which must be available at specific times. You must, therefore, coordinate with the personnel of other agencies. For example, consultation is necessary with the utilities company, central office personnel, outside plant personnel, the base materiel office, and the Air Force installations office. The latter office must have the building in good condition before you begin installing the equipment because the equipment should not be disturbed after it is in place. Similarly, dust must be held to the minimum when equipment is installed because particles of dust can make devices inoperative. Ventilating, air conditioning, and heating must also be provided before beginning the installation; thus, the utilities firm must have AC power connected into the building. The central office and outside plant personnel should have the required incoming central office lines ready for connection to the KTUs. The materiel section will have to provide tools, filing cabinets, and other necessary building furnishings.

630. Identify factors to be considered and tasks to be done in a job site survey.

Job Site Survey. A job site survey is the first planning step. This survey is made by the supervisor and the installation crew leader to determine the building layout and probable restrictions or handicaps to overcome.

Several factors should be considered, such as:

a. Accessibility. When selecting a suitable location for the cabinets, you should consider the desires of the attendant. You should also try to visualize the appearance of the installed cabinets. Inconspicuous locations are desirable, but the cabinets must be accessible for maintenance. You should provide at least 1 foot of a wall having no obstacles on the right-hand side of the cabinet and about 3 feet clearance to the front.

b. Building conduit. Is a telephone conduit or duct system to be provided?

c. Probable damage. Where cabinets are to be mounted on the floor, consider the possibility of damage from water or from blows during cleaning.

Other factors also to consider were noted above—heating, ventilation, and air conditioning. These factors have a definite bearing on the system operation and outages. In addition, consider the growth probabilities. A usual practice is to look at the current needs and allow 40 percent as the typical growth factor for 5 years of service.

Two tasks to be performed include marking the positions where equipment is to be placed and preparing a cutsheet. A usual practice for marking the location where the equipment is to be placed is to use either masking tape or identification tags. Each element permits you to write the equipment identity on it. A typical installation tag is illustrated in figure 3-1. The same method is also useful in marking the equipment cable attachment points and the equipment to be installed. Figure 3-2 shows a tag used to identify a cable and its station.

Although the preparation of cutsheets (connection sheets) might be a task for an engineer in the Air Force installation office, it may also be done by the system installer. Since you now know how the circuits operate, when you have learned the requesting agency's requirements you can do the task. Included in the job is selection of the equipment. The

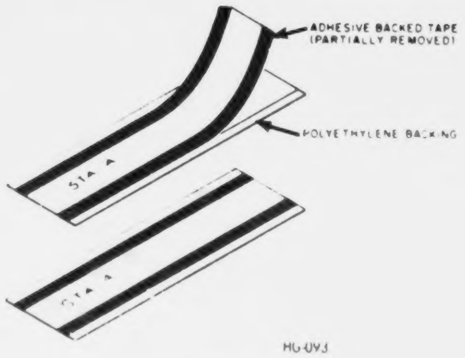


Figure 3–1. Example identification tag.

equipment to be selected must provide the features that are desired. Then, you prepare the cutsheet.

Exercises (630):

1. List three building provisions to be considered during a site survey.

2. Tell two equipment considerations to be noted while making a site survey.

3. Name two tasks to do during a site survey.

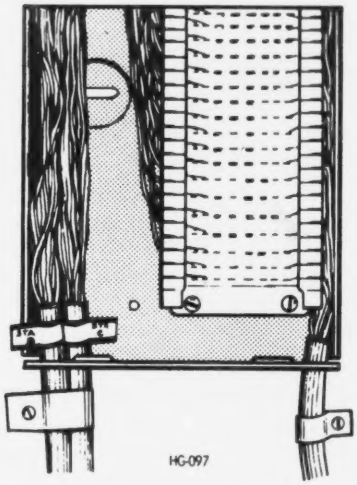


Figure 3–2. Sample tag placement.

631. Identify two typical features required when selecting a key system and compare given systems.

Selecting a Key System. Key system equipment is designed for maximum ruggedness, speed of installation, and good performance. It must have the flexibility that allows the system to be expanded or reduced as circumstances prescribe. To give circuits with superior capabilities, while keeping a fairly standard installation pattern, packaged systems were developed. As a result, your installation procedures are simple when compared to the procedures required for systems that are individually different in their connections. We know that a key system must include units that permit conversation to be held between two people (using central office line and key telephone or just two key telephones), line switching, signaling, and holding of a telephone loop (often called supervision). You should recall, too, that the units may be ordered in any combination to fit the needs of the user. The packaged system is made up of various key telephone units, mounted and strapped, and, if so desired, supplied with attached cables. Thus, your installation requires less time to accomplish. We know, too, that the packages are also available in a variety of sizes and features so that almost any service may be furnished.

Key Equipment. Since there are different systems that provide the desired features, you must consider each when selecting your equipment. We, again, do not include a complete listing of packaged systems but describe one or two which are representative packages. Hence, this presentation is only an introduction to show you some things to take into consideration when selecting the system for your requesting organization. Of course, as new needs develop more and different units and systems will be developed.

1A1 key systems. The 200G identifies a series of 20 packaged systems. No cabinet is furnished for this package. Cabinets are available for purchase if you can't locally fabricate a support. One such support for purchase is the 16C apparatus. Also, no power equipment is included with the 200G package, because you usually use some type of intercom equipment with the system, and the power requirements must be known for all units before you can select the powerplant.

It should be evident that your package must include line KTUs which provide service to CO or PBX lines. The KTU may be the type that provides service for one line or for four lines. You should recall that the 230B KTU provides service for four lines. However, it does not provide time out or flashing lamp control. The 232 KTU included in the same cabinet with the 230B KTU provides the control for time-out and flashing lamp, as well as for intermittent ringing and lamp winking. The control unit is motor driven. You should recall what the results are of such services and controls. For example,lamps flash when a call is incoming and wink when a line is being held. Signaling stops on an unanswered call when the time-out relay operates. Remember, the hypothetical package we have been considering has no intercom unit. You would select a 207C KTU to provide this feature.

1A2 key systems. Two packaged systems that use 1A2 key equipment differ from each other in their connections to a power source. One package requires a connection to an external power source, whereas the second includes a small plug-in power source. In order that the package can provide service to four CO or PBX lines, each requires four 400B line circuits and one interrupter, which provides lamp flashing and winking plus ringing signal interruptions. The 401A unit provides the intercom features. A mounting cabinet is provided for both packages.

6A key stations. We learned that the 207C Dial Selective Intercom Line Circuit is used with both the 1A1 and 6A key systems. However, it is functional only when the companion units are connected with it. The 6A may include several associate KTUs, but we do not list all since some are expansion units for a former choice. To illustrate, the 217A, Preset Conference Circuit, can be replaced with the 217B KTU. The latter unit is equal to the 217A except that it includes a time-out feature. Additional 6A units that perform with the 207C KTU are the 216A, Transfer or Group Selector Circuit; 222A, Two-Talking Link Circuit; 223A, Station Signal Circuit (for 2-talk link); 224A, Tone and Camp-On Circuit; and 227A, Audible Signal and Tone Control.

Power Equipment. Many units can be individually selected to provide the voltage distribution required for the talking, lamp, and signaling circuits of a key system. Fortunately, there is little need for you to make a selection, because the manufacturers have grouped units into a package and identified it as powerplant 101G, 101J, or RT–1B.

Telephones. Since the same key telephones are usable with all key systems, it is a small problem to select the telephones for your system. You have studied the telephone designation code which simplifies your job; yet you must know the required features in order to procure the proper cords. The cords you get must have the conductors, with the specific color code, that can be used in your particular sets. For example, slate-red and slate-green conductors are included in the telephone mounting cord when a cutoff circuit is provided for the telephone. If a Call Commander were to be ordered for use with a combined system, you would have to rearrange the leads within the set. Otherwise, they can be used without change. However, if some pushbuttons are to remain vacant, you should block them with a ring that is designed for that purpose.

Exercises (631):

1. Give two qualities usually expected from a key telephone system.

2. Tell one difference in the installation design of the 1A1 and 1A2 key systems.

3. Identify the nomenclature for the intercom KTU for the 1A1 and 1A2 key systems.

4. What is a probable identification number for a replacement KTU for the Audible Signal and Tone Control KTU in the 1A1 key system?

5. State a probable identification number for the power equipment to use with the 6A system illustrated in Foldout-3.

6. Why don't engineers order one mounting cord for all key telephones?

632. State typical information found on example cutsheets.

Cutsheets. The cutsheet shown in figure 3-3 lists connections for an example key system. Remember: This sheet can be made in other ways, with different headings and columns. It shows connections to be made at the equipment terminals and the KTUs.

Figure 3-3 shows that you must provide a 3-pair cable for four lines (tip, ring, A, A1, lamp ground and lamp). These six leads for line 1 are to be attached at terminal one through six on terminal strip A of the 230B KTU. The sheet also indicates the color coding of the conductors in the inside wiring cable. Note too that these cable pairs are inclosed in a blue binder.

Comparing this figure with foldout 1 you will see that the information is in agreement. To illustrate, terminals 1 and 2 of the 64B1–75 terminal strip connect with punchings 1 and 2 of the 230B by means of the tip and ring leads. Foldout 1 also shows punchings 1 and 2 of the 230B strapped to punchings 11 and 12.

Foldout 1 shows additional connections for the 230B—tip and ring conductors are also connected to punchings 7 and 8. These latter leads go to the central office. These connections will be shown on the Key System Strapping Sheet, as well as are the necessary strapping and power connections.

Another connecting arrangement you will use involves the ringing feature for a key system. In this situation, you deviate from the pair connecting pattern shown in figure 3-3 and use a wire-for-wire procedure. Look again at the bell connections for the 207C KTU in foldout 2. This foldout shows only one ringer for all the R connections.

According to that installation arrangement, the A terminal strip terminates all the leads extending from the studs of the selector switch, and each terminal punching serves one part of the circuit. Punchings 36, 37, 38, and 40 on the B terminal strip provide the common return to ground of the ringing circuit. First, terminal 36 of the B terminal strip is connected with tip (bell lead) of pair 22 on the type 30 terminal block by means of a red-covered wire. The B wire of pair 23, serving station 2, is also terminated at this 36th terminal. Thus, they have a common return to ground for the ringing signals. In the same manner, stations 4 and 5 have a common connection to terminal 37 on the B terminal strip of the 207C KTU. The selectivity in ringing the telephone is provided by installing the ring conductor on terminals 12, 13, 14, and 15 of terminal strip A.

Another type of cutsheet is illustrated in figure 3-4. We will interpret it, too. Consequently, you should have little difficulty when preparing such a connection sheet if you understand the information contained on this representative sheet. Figure 3-4 lists the power connections between the 101G power unit and the 230B and 207C KTUs. It also shows connections that are needed between the various units, as well as the location of the incoming central office lines. Keep the figure before you as you read the following explanation.

a. Power listings are included in the left-hand column. Punching 25 of terminal strip A on KTU 230B is connected to ground for the 105 volt AC power source. This requirement is verified if you review foldout 1. The black line drawn between the 25 (under A) and the 36 (under the B and 207C) indicates that the ringing source ground must also be provided to punching 36 on terminal strip B of KTU 207C. We can see also that the ± output of the 105-volt AC is connected only to the 207C KTU. It is connected to terminal 39 on the B terminal strip.

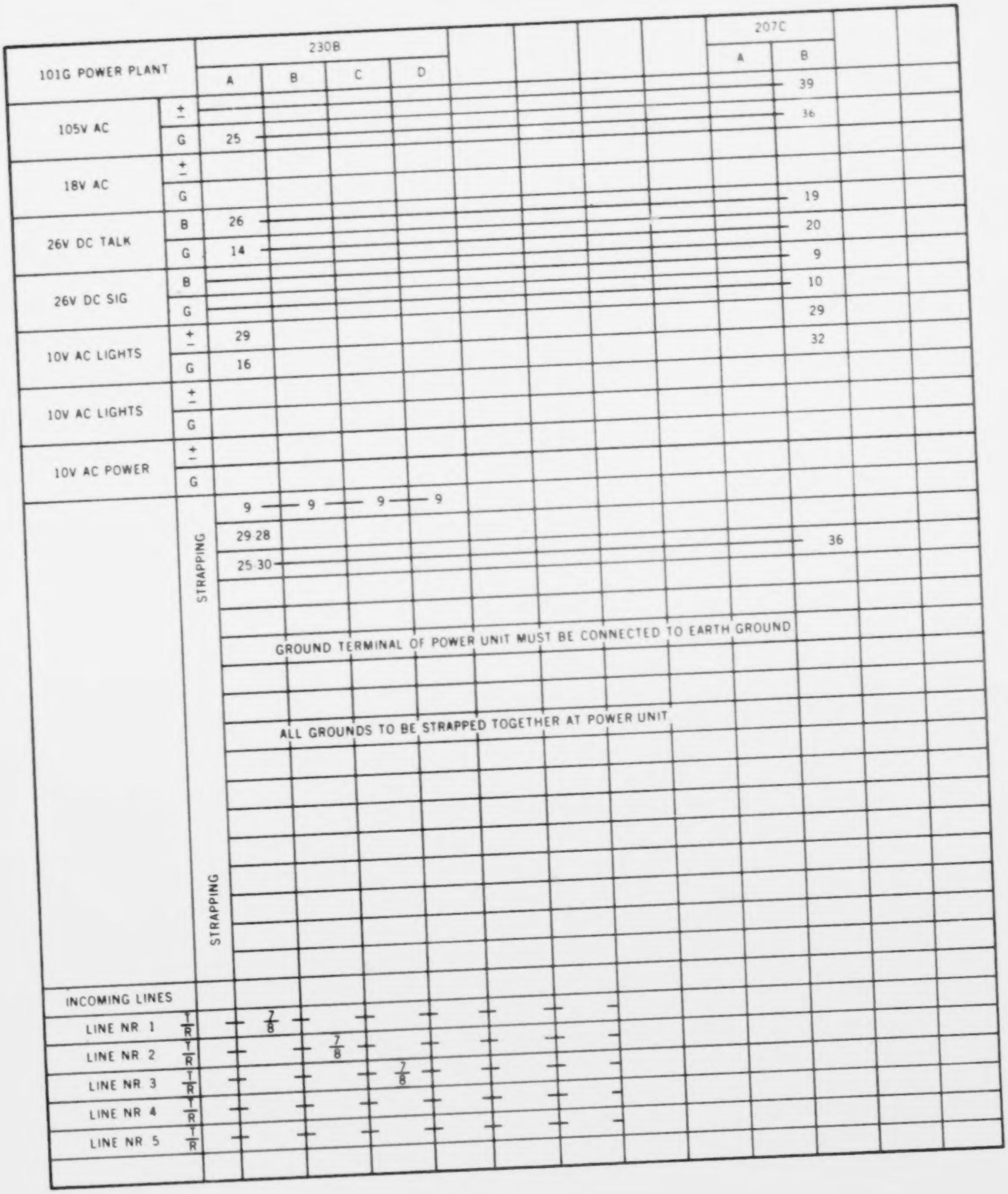
b. Twenty-six volts DC for the talking circuit of the key system stations are provided by connecting the 26 volts DC power source to punchings 26 and 14 of the 230B KTU. Remember: We referred to this power source as the "B" source (battery and ground). Likewise, punchings 19 and 20 of terminal strip B for the 207C KTU get this voltage because of interconnection with punchings 26 and 14. The incoming lines are furnished talking battery by the central office.

c. Twenty-six volts DC are also provided to punchings 9 and 10 of terminal strip B of the 207C KTU so that relay A of this unit can be operated. This provision is reflected by placing lines from the B and G blocks and in line with 26 volts DC SIG across the sheet until you reach the blocks under 207C (terminal strip B).

Feature	Lead designation	Block A 66-type connecting block			Terminal on 232B KTU	Terminal on 230B KTU	Terminal on 202D KTU	Terminal on 207C KTU
		Row	Col	Cable color Blue binder				
Line 1	T R	1 2	F	W-BL BL-W		1A 2A		
	A A1	3 4		W-O O-W		3A 4A		
	LG L	5 6		W-G G-W		6A 5A		
Line 2	T R	7 8		W-BR BR-W		1B 2B		
	A A1	9 10		W-S S-W		3B 4B		
	LG L	11 12		R-BL BL-R		6B 5B		
Line 3	T R	13 14		R-O O-R		1C 2C		
	A A1	15 16		R-G G-R		3C 4C		
	LG L	17 18		R-BR BR-R		6C 5C		
Line 4	T R	19 20		R-S S-R		1D 2D		
	A A1	21 22		BK-BL BL-BK		3D 4D		
	LG L	23 24		BK-O O-BK		6D 5D		

HG-096

Figure 3-3. Partial key system connection sheet.



101G POWER PLANT		230B A	230B B	230B C	230B D					207C A	207C B		
											39		
105V AC	±										36		
	G	25											
18V AC	±												
	G										19		
26V DC TALK	B	26									20		
	G	14									9		
26V DC SIG	B										10		
	G										29		
10V AC LIGHTS	±	29									32		
	G	16											
10V AC LIGHTS	±												
	G												
10V AC POWER	±												
	G												
	STRAPPING	9	9	9	9								
		29 28									36		
		25 30											
		GROUND TERMINAL OF POWER UNIT MUST BE CONNECTED TO EARTH GROUND											
		ALL GROUNDS TO BE STRAPPED TOGETHER AT POWER UNIT											
	STRAPPING												
INCOMING LINES													
LINE NR 1	T/R	7/8											
LINE NR 2	T/R		7/8										
LINE NR 3	T/R			7/8									
LINE NR 4	T/R												
LINE NR 5	T/R												

Figure 3–4. Example strapping sheet.

d. Ten volts AC for lighting the signal key lamps are provided by connecting the 10 volts AC power source with punchings 29 and 16 of terminal strip A on the 230B KTU and with punchings 29 and 32 of terminal strip B on the 207C KTU.

e. Figure 3-4 shows that you strap the 9 punchings on terminal strip A of the 230B with punching 9 on terminal strips B, C, and D of the 230B KTU. In addition, you must install a strap between punchings 28 and 29 of terminal strip A on the 230B KTU. Furthermore, punchings 25 and 30 on terminal strip A are strapped and then connected with strapped terminal 36 of terminal strip B of the 207C KTU. The remaining strapping requirements are clearly stated; therefore, you should know what procedures to use.

f. The next section of our cutsheet shows the termination of three incoming lines. All lines are attached to the 230B; NR 1 to terminal strip A, NR 2 to terminal strip B, and NR 3 to terminal strip C. It is evident, too, that tip of each line must be connected to punching 7; and ring of each line must terminate at punching 8.

Systems that are ordered as a package are already mounted and strapped, thus eliminating most strapping and connections. We know, too, that packages are available in a variety of sizes and features so that almost any service can be furnished, prewired. (Refer to Chapter 1.)

Exercises (632):

Use figure 3-3 to answer exercises 1–3 and figure 3-4 to answer exercises 5–7.

1. To what 64B1–75 terminal strip A terminals do tip and ring for pair four terminate?

2. Give the color code for the lamp pair for line 3 in the inside wiring cable.

3. Identify the 230B punchings to which the A–A1 pair for line two connect.

4. To what terminal strip punching must you connect the bell load when providing ringing service for station two?

5. Tell the 207C KTU punching and terminal strip that provide ringing current for the key sets bell.

6. List the common terminals for B battery at the 230B and 207C KTUs.

7. Identify the 230B KTU punching commonly used for terminating the central office incoming ring conductor.

3-2. Placement of Apparatus Cabinets and Equipment

Our discussion of planning to this point has covered some of the operations in preparation for installing a key system. Before the equipment can actually be installed, we must do some on-site planning, as you will see in the following paragraphs.

633. State typical on-site specifications to be considered when preparing to install a telephone key system.

On-site Specifications. Installation of the apparatus cabinets requires a considerable amount of good judgment on the part of the installer. Several factors should be considered.

a. Support. You must provide adequate support for them; inside plaster block or similar soft materials and temporary office partitions are not suitable. Wall-mounted cabinets should be about eye level to an average person.

b. Building conduit. If a telephone conduit or duct system is provided, locate the cabinets near an outlet.

c. Space. Locate the cabinet so that there is sufficient space for the gate to open. Yet, a location close to the wall or partition is usually desirable for cabling purposes.

d. Vibrations. Avoid placing cabinets containing relay equipment in spaces subject to vibration.

e. Heat. Avoid locations near radiators, steam pipes, registers, etc., which would subject the equipment to excessive heat.

f. Light. Good light should be available so that the installation and repair personnel can see the operation of the equipment.

g. Ventilation. The apparatus cabinet may be placed in a closet or small room if it is opened a few times during the day.

h. Power. There must be provision for power (110 to 120 volts) close to the apparatus cabinet. The power-apparatus room should be well lighted, dry, and as dust free as possible. Further, it should not have excessive temperatures, should be centrally located and should be large enough for a person to work around the installed equipment.

Excercises (633):

1. At what height should key systems be?

2. Where will you place most key system cabinets?

3. State five acceptable room conditions for telephone equipment.

634. Given an example installation, indicate probable procedures to be used and typical results to expect.

Installation Procedures. Normally, the material needed for you to complete the task of installing the telephone key system has been forwarded to the installation site by your home organization or some other responsible agency. As part of your preliminary installation activities, you should thoroughly inventory the bill of materials. If the material was stored at your home organization prior to its shipment, it was inventoried by you or your supply personnel. However, during the materials shipment to the installation site, suppose some of the material gets lost. If this happens and you did not perform an inventory before starting your installation, you may have a work stoppage.

When you and your crew have completed your inventory and are satisfied that all the material is on hand, it is then the responsibility of the communications-electronics (C-E) officer to provide adequate storage. You may be able to store some or all of the material at the site, which is the ideal situation.

Experience has shown that it is worth your time and effort as a supervisor to review job specifications before doing the installing. One main reason for reviewing specifications prior to installation is that during this phase, your team members are looking to you for a decision on specific matters and you must give them a timely and accurate decision.

Visualize the placement of the equipment that you will install determine the distance between the equipment and the walls. If you prepare and review a floor plan carefully, your task in supervising the installation will be greatly reduced since you will be familiar with what equipment goes where.

You should assign your team, dependent upon its size, to various installation tasks rather than having the entire team attempt to work on a single phase of the installation. The reasons for spreading your people out to various installation projects are twofold: (1) it speeds up specific installation tasks, and (2) it reduces the possibility of personal injury since the team members are not "walking over one another" when performing their duties.

Having assigned your team members to their various duties, you should then personally inspect, or appoint a responsible individual to inspect, the tools and personal safety equipment of each team member to insure safe working conditions. During the inspection some important items to check are frayed cords on ramsets and electrical drills and the serviceability of small handtools. Furthermore, you should check to insure that each member uses safety goggles when operating drills and ramsets.

See that they handle the equipment with care to prevent damage to its covers, terminals and cables. If apparatus cabinets are required, mount them first. Mount each specific unit in its marked location, using the appropriate fasteners and according to the approved specifications. Remove the cabling from its shipping assemblies and position each connector beside the applicable equipment. Place the cables uniformly to provide a neat appearance and so that they are out of the way of traffic.

Connect the power cable(s) to the power unit. Connect the equipment ground to an approved ground. If the available 110 VAC outlet is not a 3-wire grounded type, install an adapter and terminate its ground terminal at a frame ground.

During installation, inspect the work of your people as they install the equipment. The obvious purpose is to discover and correct mistakes. If you wait until the entire installation is finished before you perform an inspection, it can be extremely difficult to correct mistakes with all the equipment in place.

Exercises (634):

1. Tell the probable first procedure to do at the site where a telephone system is to be installed.

2. What procedure should insure that the inventoried equipment will be properly installed?

3. List two results of an effective team assignment.

4. Give a high-priority requirement for the telephone system installation team.

5. Name a valuable document for a telephone system installation team.

3-3. Installation of Cables

Conductor installation procedures are standard with any type of communications installation. While the main objective may be to get the equipment to operate, keeping it trouble-free is also important. Neatness makes the job of maintenance so much easier. Clean, solid connections rarely vibrate loose to cause those troubles which are so difficult to locate.

635. Identify example precautions for cables and cable conductors when installing a telephone key system.

Cable Installation Precautions. The following precautions should always be taken by an installer:

a. Fasten all screws securely to a solid base.

b. Make your cable runs either horizontal or vertical; never place them at an angle.

c. Clamp the cable where it lies straight rather than at a turn. The turn for a 25-pair cable should have about a 4-inch

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radius with a clamp on the straight section each side of it. No turn should be so sharp that it appears squared. If two cables of different size make the same turn, make the proper turn for the larger and conform the smaller to this pattern.

d. Leave sufficient slack at each connection to permit an accidentally broken wire to be reconnected.

e. All connections at a screw terminal must go around the screw in a clockwise direction; that is, the same way in which a right-hand threaded screw turns to tighten.

f. No more than 1/8 inch of bare wire should show between the screw and the end of the insulation. However, some bare wire must be seen at this point, for the insulation must not be under the screw. Figure 3-5 illustrates such a connection.

g. The wire should be wrapped no more than three-fourths of the way around the screw. This action prevents the wire from being cut off when tightening the screw.

h. The end of the wire is to be no longer than 1/8 of an inch. It can be broken off under the washer or cut off with diagonals.

i. Never put more than one wire under each washer.

j. To prevent many future troubles, place the cord spade terminals under the bottom washer of the 44A connecting block. The shank of the spade must be inserted so that it rests down in the slot; this position keeps it from turning with the screw. Then, the cable conductors must be placed between the washers.

Exercises (635):

1. Give two requirements for installing telephone cable.

2. State the requirement for a to-be-terminated conductor's length.

3. What is the reason for placing a wire around a screw clockwise?

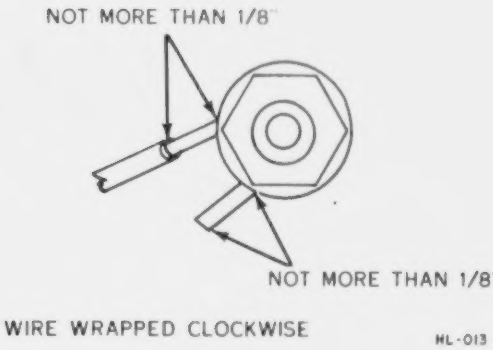

Figure 3-5. Screw terminal connection requirements.

4. How much "shiner" should be showing between a terminal and the attached wire's insulation?

5. How many wires can be connected to a two-washer screw terminal?

636. Cite identifying features of key system inside wiring cable.

Identifying Features. When a key system is installed, cables containing many pairs are needed. The greater the number of terminations the greater the required understanding and ability on the part of the installer. The installer must be familiar with the cable used in installing key telephone systems.

Inside wiring is polyethylene insulated conductors (PIC) cable. Cables containing 25 pairs of 22-gauge, single-strand D-color-coded wire are usually used. Yet, cables containing more than one group of 25 pairs are functional for key systems too. In the multiple-group cables, each 25-pair group contains a binder wrapping around it; thus, it is kept separated from the neighbor group or groups. To illustrate, a 50-pair cable consists of a 25-pair group which has a blue-white binder and a 25-pair group which has an orange-white binder. Figure 3-6 shows this grouping. Note that the solid colored insulation has a dash of a second color to identify the specific conductor. For example, the ring conductor for pair one is solid blue but has a dash of white, while the ring conductor for pair two is solid orange with a dash of white. All pairs are stranded around each other to form the cable.

Using colored insulation on the conductors of a cable makes installation easier because it simplifies differentiating between conductors. It also results in standardization in your installations. This makes it easier to maintain equipment served by cables having a large number of conductors. The coding system is determined by the type of insulation, the number of conductors in the cable, and the arrangement of the conductors.

Figure 3-7 illustrates a fanned cable at a type-30 bridging terminal. At the top a *running* cable is shown and at the bottom is shown the key cable. Remember, although cables are identified differently they all have conductors that are color coded.

Exercises (636):

Use figure 3-6 to answer exercises 1–3.

1. Tell the binder color for pairs 76–100 of an inside wiring cable.

2. Give the color of the insulation for the tip conductor for pair two.

Pair	*Ring* wire	*Tip* wire	Binder color for 50, 75, and 100 pairs
1	BL-W	W-BL	BL-W
2	O-W	W-O	
3	G-W	W-G	
4	BR-W	W-BR	
5	S-W	W-S	
6	BL-R	R-BL	
7	O-R	R-O	
8	G-R	R-G	
9	BR-R	R-BR	
10	S-R	R-S	
11	BL-BK	BK-BL	
12	O-BK	BK-O	
13	G-BK	BK-G	
14	BR-BK	BK-BR	
15	S-BK	BK-S	
16	BL-Y	Y-BL	
17	O-Y	Y-O	
18	G-Y	Y-G	
19	BR-Y	Y-BR	
20	S-Y	Y-S	
21	BL-V	V-BL	
22	O-V	V-O	
23	G-V	V-G	
24	BR-V	V-BR	
25	S-V	V-S	
26-50	Repeat first	25 colors	O-W
51-75	Repeat first	25 colors	G-W
76-100	Repeat first	25 colors	BR-W

HG-095

Figure 3–6. Inside wire color coding.

3. Tell the color of the insulation for the ring conductor for pair 60.

4. Identify two cables terminated at type-30 bridging terminals.

637. Cite work precautions and tasks used when placing key system cables.

Work Precautions. Review the installation specifications for the proposed cables route. You may find a problem area that was overlooked in the original survey, or perhaps new

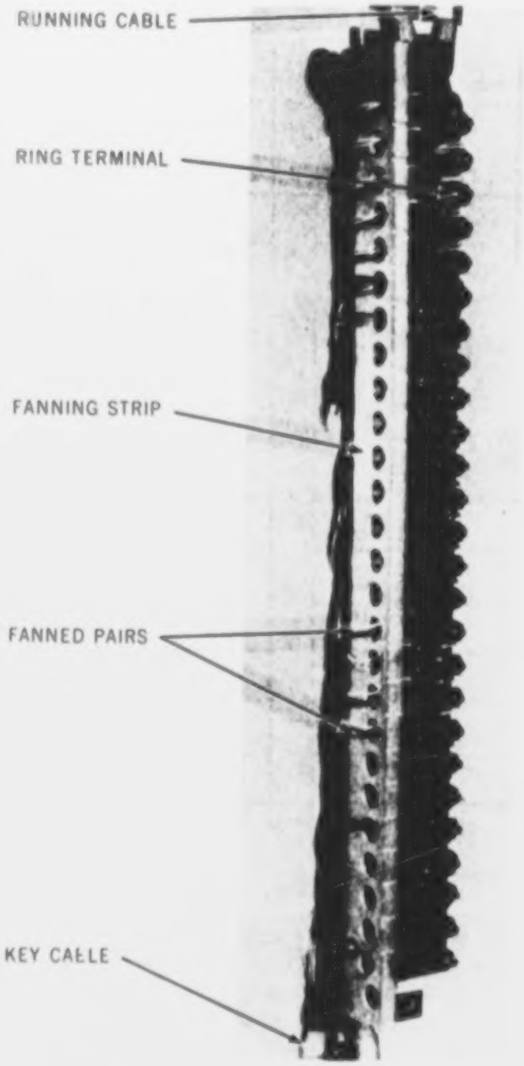

Figure 3–7. Fanned cable at type 30 bridging terminal.

difficulty has been added during the time lag which occurs between the original placement and this actual termination stage. It may be necessary to reroute the cables. Be sure that you clear any evident problem before beginning the cable placement.

Before, during, and after work make sure that you practice safety. Injury and damage result from carelessness and/or a lack of knowledge. It is not necessary that we list all the things that can be considered safety hazards because most are not the cause of accidents unless handled improperly by a human. In other words, most accidents are the result of human errors.

A sample list of accident causes with which you may be concerned follows:

- Careless housekeeping. Examples of what results from careless housekeeping are lost screws and lost and broken tools.
- Using the wrong tool for the job, or using a tool improperly. To illustrate, using a small blade screwdriver in a large-headed screw can result in a physical injury.
- Leaving a soldering iron connected to the power source when not being used.
- Placing a soldering iron where it can be accidentally touched.
- Failing to block high-voltage terminals to personnel or failing to identify these terminals adequately.

Tasks. Some of the procedures you use in preparing the cable for placement may also appear as safety practices. Hence, everything you do involves safety. The following cable preparations show evidence of the need for your close attention when placing cable.

a. Do not leave cable reels unattended while cable is being removed because this act may result in damage to the equipment or cable, or injury to some person.

b. Remove only as many cables as can be handled conveniently at one time.

c. Locate cable reel in a position which prevents the cable from chafing on adjacent reels or strands during cable removal.

d. To keep waste to a minimum, check the length of cable on the reel and the cable type against the total footage and the type cable to be installed. Plan the cable positioning (cable run) accordingly.

e. Do not cut cables to the lengths shown in the cable running list; instead, place the cables first, allow enough for butting and forming, and then cut.

f. Do not make turns or bends in cable at any time at less than the specific minimum bending radius for the cable; this is particularly important when the cable is running free and unsupported.

g. Inspect the plastic inside wiring cable for cuts and abrasions as it is coming from the reel.

Treat damaged sheaths at the time of discovery. If the cable is damaged to the extent that the bare conductors are exposed, remove the cable and use it for a shorter cable run which does not require use of the damaged portion. If the plastic sheath is damaged but the conductors are good, repair it with a layer of tape (rubber and/or plastic).

Cables that are properly insulated and have a suitable protective covering may be clamped directly to most surfaces. Clamps used for this purpose are similar to the pipe straps used for the installation of conduit. Position the clamps over the cable and secure to the mounting surface, using wood screws, toggle bolts, or expansion bolts, as required. Space clamps to provide adequate support without sag. The methods for installing and securing interior cables vary, depending on the type, size, and the amount of cable.

Another method for securing the cable is by sewing it to the support with waxed No. 12 twine. A flat plastic lacing is sometimes used in place of regular sewing twine. This lacing is used in the same manner as sewing twine, and, since it is flat, it does not have the tendency to cut into the insulation of the cable. It may be used with a wide range of cable sizes. Zippered tubing and spiral-cut plastic wrapping are additional fastening materials available for use in place of sewing twine. Where cables or conductors may come in contact with rough or sharp edges, use tubing or wrappings to provide additional protection.

Exercises (637):

1. State a task necessary for insuring reliable cable placement.

2. Tell two soldering iron precautions.

3. List two safe practices for cable reels.

4. Identify three acceptable practices for cable handling tasks.

5. Give two methods for securing cable in place.

638. Identify typical termination methods and example tasks for each listed.

Termination Methods. Once the cables are positioned and their proper location verified, you terminate them. Several steps are performed, however, before the conductors are attached to the terminals.

Probably the simplest terminating method is the plug and receptacle type. The mating devices permit rapid replacement of units with a minimum of effort. Figure 3-8 shows one device developed for providing flexibility to telephone equipment. Wiring from a cable is attached to lugs. You can see lugs to the left of the mating device in our figure. The right-hand device also has them but they are not visible. The pictured devices have 32 metallic contacts: 16 contacts on each side of an Amphenol head (the right-hand mating device) or 16 contacts that embrace a depression. Within the depression you should find a guiding element, called a key, which insures that the male plug is inserted onto the mating receptacle correctly. When the two devices are pressed together, each metal contact rubs its mating element.

Figure 3-9 shows the receptacle with which you are more concerned. It has a unit with 25 contacts on each side of the depression. This unit and two more just like it are attached to the connector cable. The three units were illustrated with the Call Commander and the mating elements in figure 1-15. You will see many ways of providing a quick-disconnect. All types accomplish the same function, although their design, their contact arrangement and numbering, and their attachment may differ.

Figure 3-7 showed a second cable termination, which we briefly considered. Figure 3-10 illustrates another terminated cable. For the cables shown here, it is evident that before you can terminate the conductors, you must expose them and fan them out to the appropriate terminals.

Despite the manner in which we are covering the installation procedures, you are surely aware that we are not establishing the standard for you to use. You use the procedure created by your organization.

Close inspection and supervision during the termination is a must, especially if any team member is new at the job. As you are aware, individuals will make mistakes because of inexperience. If these mistakes are not caught early in the installation, then a lot of time, effort, and materials may be wasted, which could result in your not completing the installation in the time allotted.

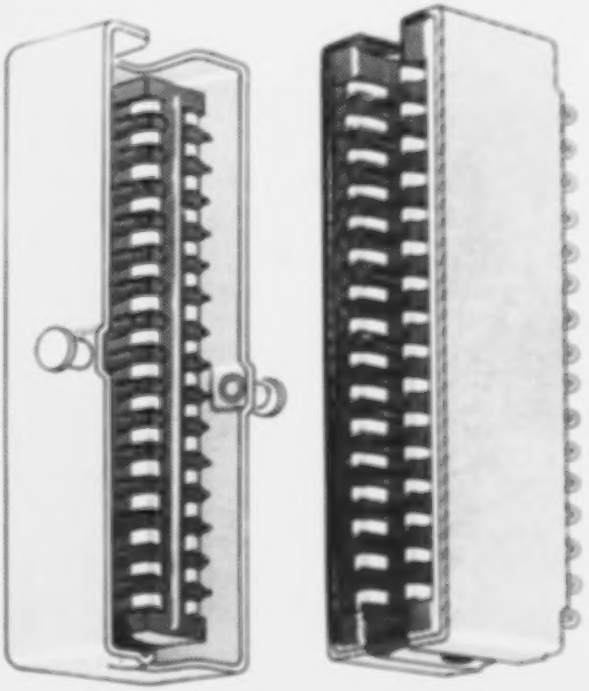

Figure 3-8. Example cable connector.

Exercises (638):

1. Name two cable termination methods.

2. Tell two typical tasks to the plug and receptable termination method.

3. Tell three tasks to the fan and form termination method.

639. Name tools and actions to use when "ringing" a telephone cable.

Cable Termination. We shall look at the procedures included for terminating a fanned and formed telephone cable. Included are:

1. Ringing and butting.

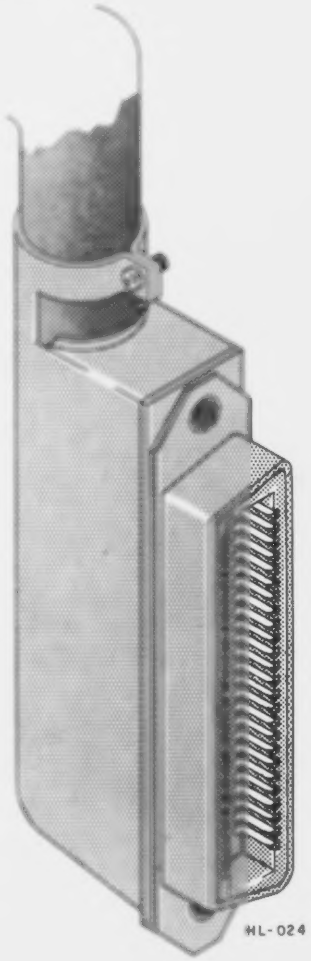

Figure 3-9. Key system cable connector.

2. Fanning and forming.
3. Terminating.

Ringing and butting the cable. The term used to describe the circular cut made through the cable covering at the point where the outer sheath is to end is "ringing the cable." A second necessary step is wrapping the cut sheath. This procedure is referred to as "butting."

Methods for ringing the cable vary and are dependent upon the outer covering of the cable. Start the ringing procedures after the cable has been secured in its final position. Only then are you sure that the slack is adequate. The location of the cable butt depends mostly upon the location of the terminals and terminal strips. The butt must be a sufficient distance from the terminating point to allow for the minimum bending radius; and if several cables are to terminate at a common point, try to make the butts even. Also, the butt must be in a position which allows the conductors to be fanned out for connection with the terminals. Yet it must not be so far that excessive conductor is exposed between the butt and terminals.

After the butt location has been determined, mark that point on the cable sheath with a soft lead pencil. Mark it heavily so that it can be easily seen.

To remove plastic sheath use diagonal pliers to cut the insulation at the end of the cable for about 1 inch; then you can extend the sheath opening and search for the nylon rip cord. Having found the rip cord, grasp it with long nose pliers. Wrap it around the long nose pliers by rotating the pliers two or three turns. Pulling the rip cord with the long nose pliers cuts the sheath.

NOTE: Using fingers to pull the nylon cord to cut the sheath may also result in cutting your fingers. Rip the sheath with the nylon cord until you arrive at the butt mark. Now, use the diagonal pliers to cut the ripped sheath at this butt mark.

Exercises (639):

1. Name two tools that permit safe cutting of a plastic cable sheath.

2. What cable ringing procedure enables you to locate the nylon rip cord?

3. Tell the procedure by which you rip the sheath with the nylon cord.

640. Give two purposes for butting a cable and example elements when doing it.

Butting. Butting of an interior cable provides protection against the breakage of conductors at the sheath opening and helps to prevent moisture from entering the sheath.

A simple method for doing this is by placing two layers of plastic electrician's tape around the open cable end. Place the tape so that approximately half of its width is on the sheath and half the width is on the conductors. Wrap the tape tightly around the cable and form it as neatly as possible. The cable at the top of the 66 bridging terminal in figure 3-10 shows a tape wrap example.

A second method for protecting the conductors as they leave the cable butt is by closing the loose end with a plastic tie especially designed for this purpose.

To prevent the conductors of a pair from separating and forming split pairs, twist the two mates together after completing your cable butt. Remember this action when using plastic insulated cable because the conductors untwist easily when they are free from the sheath.

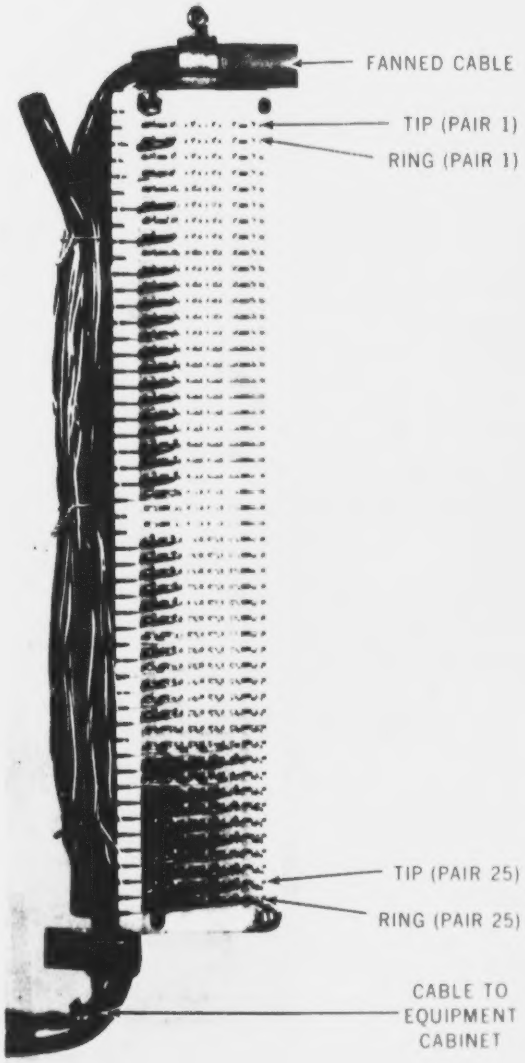

Figure 3–10. Fanned cable at type 66 bridging terminal.

Exercises (640):

1. Tell two undesirable conditions which should be eliminated when a cable is properly butted.

2. Identify two devices used to butt a telephone cable.

3. How much of a 2-inch tape wrap should cover the cut cable sheath at the butt?

641. Identify typical devices and example fanned conductor requirements.

Fanning and forming. The conductors must be fanned out into the form which is to serve as a guide to their connection at the terminals. A fanned form is defined as a group of conductors originating at the butt of the cable and ending at the equipment terminals. This arrangement of the conductors must be such that it does not interfere with the installation, operation, or maintenance of the equipment. In addition, the form should provide adequate protection for the conductors and present a neat appearance.

Since there are many different types of terminating blocks, it is evident that you will use several forming arrangements. At the type 30 terminal unit, you place the running cable on the side where the board fanning strip is installed. The cable should also extend 2 inches below the type 30 terminal before you begin to fan the conductors. The running cable is to be butted in such a manner that the end of the sheath is below the strip and at a distance that permits room for skinning and terminating the first conductors. Figure 3-9 illustrates a sample fanning arrangement at the type 30 terminal. Accordingly, pair 1 has the shortest conductors and pair 25 has the longest conductors. Since it is more difficult to fan long conductors than short conductors, excess wire should be cut off, leaving only a sufficient length with which to work. Usually, a wire that extends 6 inches beyond the face of the extreme front edge of the fanning strip is sufficient for the skinning and terminating operation. However, wires that are not to be used must not be removed. They are spare wires. Be sure to keep the wires paired while completing the fanning operation, hence arrange them to conform with the D color code.

With a 66 type bridging terminal, illustrated in figure 3-10, you also first place the wire through the fanning strip before placing the wire in position at the terminal. The fanning strip is not as evident in the latter figure as in figure 3-9, but it is at the left of the unit and beside the fanned form. Note that pair 1 is terminated at the top and pair 25 is terminated at the bottom.

Another fanning arrangement is shown in figure 3-11. It shows the fanning arrangement at a 44A connecting block. You can see the pairs for terminals 1, 2, 6, and 7 pulled out above the connecting block. Below the illustrated connecting block are four pairs of conductors: three pairs are attached to the illustrated block and one pair attaches to the connecting block to be installed subsequently to the one shown.

NOTE: The illustrated block is No 4 because the key cable is shown above the block. However, you may make installations where the key cable enters from below and the No. 4 block is installed as the lowest of the four blocks.

Exercises (641):

1. What in a fanning strip permits conductors to be fanned through to the appropriate terminal?

2. How are fanned conductors at a bridging terminal bound together?

3. Tell a terminal difference for the 30 and 66 type bridging terminals. Refer to figures 3-9 and 3-10.

4. Give the conductor length requirements for the illustrated bridging terminals.

5. Why must you not cut the unneeded conductors?

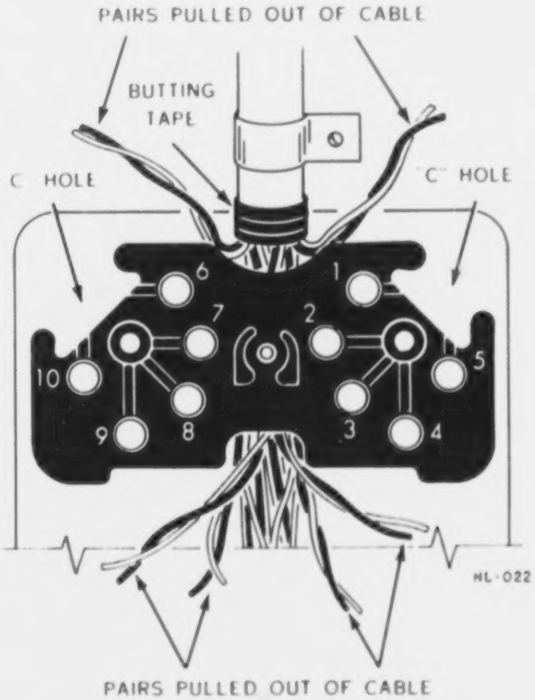

Figure 3-11. Fanned cable at 44A connecting block.

6. Which conductors in figure 3-11 must be kept long?

642. Identify typical bridging terminal terminating methods, and give tasks and requirements that apply to them.

Bridging Terminal Terminating Methods. Before beginning to terminate the wires, review the cutsheet and, if necessary, make up a set of instructions for use. This sheet and the instructions should give adequate guidance so that the crew will do reliable service. Remember: It is your responsibility to insure that the installation is accurate.

Fanned wires that must have insulation removed are always skinned and cleaned at the terminal strips as they are being terminated. A conductor that has had too much insulation removed, one that has more than 1/8 inch of metal showing beyond the terminal, is referred to as a "shiner." You must take care to prevent shiners at the terminals.

Terminating at the type 30 bridging terminal requires you to skin and clean the wires. Then, you insert the wire through the hole of the fanning strip. Next, place the first conductor for each terminal under the bottom washer, and place the second conductor under the second washer. Use the instructions of objective 635 in performing this termination. Do not tighten the bottom nut until all conductors that are to be under it are in place. When tightening a nut make sure that only one conductor is under each washer; otherwise you will break one of the two wires that are beneath.

Remember, you use the conductor color code when completing these terminations. For example, the ring wire for pair 1 is blue-white and is to be placed under the bottom washer of the right-hand terminal post which is closest to the butt of the cable. The mate (tip) wire for pair 1 is white-blue and is to be placed under the bottom washer of the terminal post that stands to the left and above the ring terminal. Likewise, you attach an orange-white conductor to the right terminal of pair 2 and its mating white-orange conductor to the second tip terminal.

Continue making the terminations for the running cable following the prescribed pattern. Insert each conductor in its hole of the fanning strip, skin the insulation from the wire, place the proper wire under a washer, and tighten the nut against the two washers when both conductors are in place (when two conductors are required at the terminal post).

The terminating procedure for the running cable is followed when connecting the key cables to 30 type terminals except that the conductors are placed under the washers that lie under the top nut.

A much faster, easier method is shown in the terminating pattern used with a type 66 bridging terminal, as illustrated in figure 3-10. You place the wire in the small opening below the upper finger on one of the projections (clips) for the terminal. Of course, you first insert the wire through the fanning strip before placing the wire in this position. Figure 3-12,A, shows the wire in position in a terminal clip before it is forced within the lips of the clip. Figure 3-12,B, shows the tool after it has pressed the wire down, thus completing the termination. It is evident that you do not skin the wire for this type of terminating operation. (NOTE: A sharp edge on the blade of the tool cuts off the excess wire. The blade must go onto the clip straight to prevent damage to the tool or to the terminal or both. If you want to install a wire that is to continue to another connection, use the tool in a manner which allows the dull edge of the blade to rest against the wire as it is being pressed down.)

NOTE: The 714B tool (fig. 3-12) is designed with a reversible blade.

Terminate the running cable at the 66 type bridging terminal in the manner illustrated in figure 3-12. Place the first conductor (tip for pair 1), which is white-blue, in the terminal at the left first row. Then place the ring wire (blue-white) for pair 1 in the terminal at the left of the second row of terminals. In the same manner, the white-orange conductor for pair 2 is installed in the terminal to the left of the third row, and the orange-white wire is connected in the first terminal of the fourth row. Figure 3-10 also shows the position of terminated wires on a 66 type bridging terminal.

Connector cables have the even-count arrangement and the same color pattern at the instrument and the apparatus cabinet. These cables have an Amphenol connector on one or both ends. The single-ended connector cable has the connector on the telephone instrument end. Consequently, the connector has eliminated the need for connecting blocks. You terminate the open end of the single-ended connector cable at the bridging terminal while using the standard installation practices and the associated connection sheet. And as noted earlier, quick-connect terminations are simply, easily and quickly made. Hence, we have no further explanation of this task.

Exercises (642):

1. What is the installation task that can cause a short circuit when the "shiner" is too long?

2. What is the "shiner" requirement?

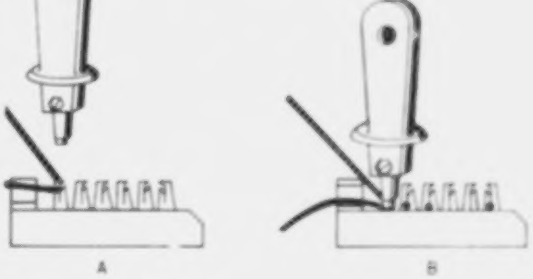

Figure 3-12. Terminating a wire on a 66A terminal.

3. Identify the guiding structure of each bridging terminal through which you pass the to-be-terminated conductor.

4. State the screw-wire requirement for a type 30 bridging terminal.

5. Tell the requirement that applies when terminating conductors at all bridging terminals.

6. Compare type 30 and type 66 terminating procedures.

643. Given an example connecting block and cord termination, specify installation requirements, tasks, or factors that relate to each unit.

Connecting Block and Cord Termination. Terminating conductors on a connecting block is comparable to the 30 type terminal. However, before you can tighten any screw against the washer you must install the connecting blocks. To illustrate, we previously described fanning of the wires at the 44A block (No. 4). After having pulled the proper wires, you mount the 44A terminal block on the backboard. This terminal block fits above many pairs of conductors (all except the ones which you fan out are to remain under the block). Review figure 3-11 to see the two pairs that do not lie under the block. The block of figure 3-11 also reveals that the C holes must be at the top when mounting the 44A block. Be sure that you turn the self-threading mounting screws until they rest completely down in the countersunk holes. Otherwise, you could cause a short or ground to the to-be-installed cord conductors. Now, you can complete the terminations. You also use the D color code when terminating the key cable pairs at the 44A connecting blocks. An exception to be noted with these terminations is that the conductor is placed between the two washers rather than having one conductor under each washer. Similarly, you want no excess wire. Furthermore, you tighten the screws only when all attachments are completed. Hence, the screws on the No. 1 connecting block are tightened when the telephone cord conductors are also installed under the screws. Figure 3-13 shows a front and rear view of four connecting blocks which have terminated a key cable and a telephone cord. The view to your left shows the screw numbers and wires terminated at each. The right-hand view shows how the cables and conductors are fitted beneath the connecting blocks.

Let us concentrate for a minute on the cord installation procedure. The conductors of the cord are to be divided into two groups. The group of conductors for the left-hand side of the connecting blocks (using our installation where a No. 4 block is mounted at the top) should include the wires that are to be terminated under the screws identified as 6, 7, 8, 9, and 10 on connecting block 1. You should remember that the cord conductors are terminated as specified using a color-coded pattern. Between the two groups of conductors should stand the wire link for holding the cord. Figure 3-14 identifies this mounting cord wire link. Lay the cord conductors under the edge of the block and bring them through the C hole of the block to which they terminate. It is

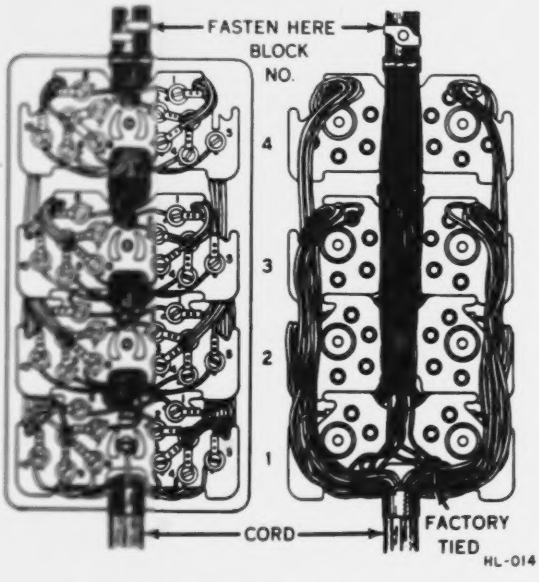

Figure 3-13. Four connecting blocks terminated.

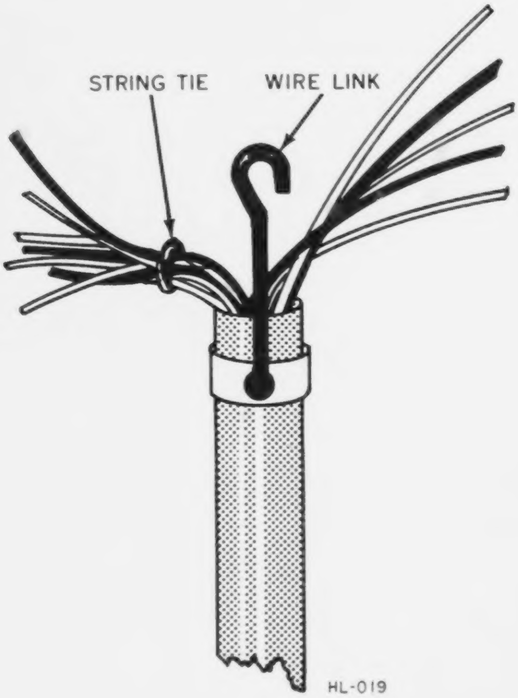

Figure 3-14. Connecting block end of mounting cord.

evident that the conductors for each block are of different lengths to permit them to be connected under screws which are in a radiating pattern from the C hole. Likewise, the cord design enables you to connect the conductors without crossing either another cord conductor or a cable conductor. You should first fasten the wire link to the center screw of the No. 1 block. Then insert the spade terminal of each conductor under the washer of the proper screw so that the shank of the terminal lies in the slot formed in the 44A connecting block. Now tighten the screw. The slot and tightened screw prevent the spade terminal from moving. Remember: There will always be some screws on the connecting blocks that are not to be connected with the telephone. Conductors that are not to be used should be taped out of position in a manner that will prevent faults in the system and so that all tape is concealed by the connecting block cover.

The terminals for the more modern connecting block (for example the 66E3–25 block) are comparable to the terminals of the 66 type bridging terminal. They press through the insulation to make contact with the wire. Further, the terminals are in parallel rows instead of in a radiating arrangement around the C holes.

Exercises (643):

1. What cable is terminated at the connecting block?

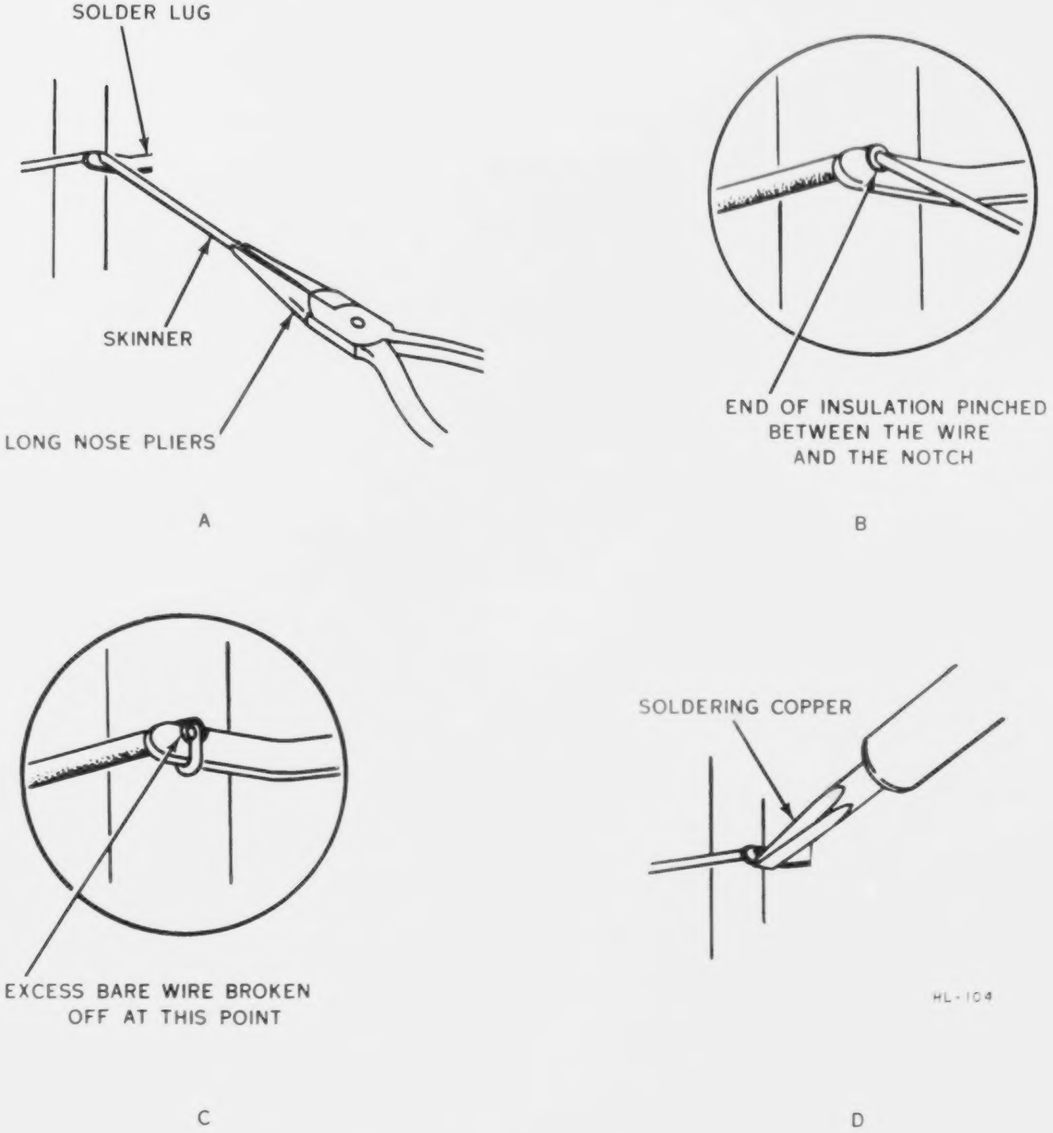
SOLDER LUG
SKINNER
LONG NOSE PLIERS
A
END OF INSULATION PINCHED BETWEEN THE WIRE AND THE NOTCH
B
EXCESS BARE WIRE BROKEN OFF AT THIS POINT
C
SOLDERING COPPER
HL-104
D

Figure 3–15. Connecting wire to terminal lug.

2. What two tasks are required to prepare a key cable conductor for terminating at the connecting blocks for text figure 3-13?

3. Which connecting blocks in text figure 3-13 are connected with the telephone?

4. Identify a terminal (or terminals) in the connecting blocks of text figure 3-13 which don't have a cord conductor attached.

5. State the wire terminating procedure required at each screw of a connecting block.

6. With the mounting cord, what is the first task to do?

7. At the connecting block, compare mounting cord terminating with the key cable terminating procedure.

8. How should you handle the cord and cable conductors at a connecting block to insure proper connections and neatness?

644. Specify tasks for providing a soldered connection and cite characteristics of a quality connection.

Soldering Connections. The most difficult terminating method is done with a soldering iron or gun. Fortunately, you seldom make one of these connections. Placement of each conductor also conforms to the color code requirement which is designated in the installation specification. You have learned soldering and the tools used in performing it. We, therefore, briefly add to those instructions.

One method for determining the skinning point on the conductor to be installed is to bring the wire over the terminal lug and grasp it with the skinning pliers at the front of the terminal. Figure 3-15,A, illustrates this procedure. Press the wire against the notch in the lug to mark the insulation. Figure 3-15,B, shows a pinched conductor in detail. Release the wire and skin it from the mark to the end of the conductor. Be careful not to damage the wire. Skin plastic insulation about 1/16 inch beyond the terminal bend so that the plastic won't be in the notch when you heat the terminal. Be sure that a wire is bare before forming it on the terminal and attempting to solder it. Solder does not form a good seal if any tarnish is on the wire. Bring the wire to the left side of the terminal and into the notch (see fig. 3-15,C). Bend the wire so that it fits snugly against the terminal. After all wires have been connected, press your soldering iron to the right side of each terminal for soldering. Figure 3-15,D, illustrates the termination procedure. When soldering a row of terminals, start at one end and work toward the other, in a manner that prevents the hot tip of the iron from touching a terminal which has already been soldered. Examine each soldered connection in the completed rows as the work proceeds, and make sure that the proper wire has been connected to the correct terminal and that each is well soldered. Resolder all connections that are unsatisfactory.

Telephone system power equipment terminals often require the soldering illustrated in text figure 3-15. Remember, the appearance of a telephone installation may cause the user to think your system is defective, although the equipment works. If the connections are made neatly and correctly and the cables are uniformly placed, everybody will be satisfied. There is a statement that fits very well here: "If a job is worth doing, it is worth doing well, and safely!"

After having made all connections, including power and incoming CO lines, examine your installation closely to see that all units are wired neatly and correctly. This is often referred to as "preoperational check." It should be thorough to disclose loose or undesirable connections.

Exercises (644):

1. State the procedure by which you measure and mark a conductor to indicate the spot where skinning of the insulation shall begin.

2. Tell the action to take to insure that a conductor to be soldered is clean.

3. List typical characteristics of a quality telephone cable installation.

CHAPTER 4

Maintenance and Testing of Key Telephone Systems

THINKING OF, and preparing for, trouble in a communications system is best done before the trouble occurs. One opportunity for thinking about key system troubles is before you in this chapter. Although we cannot describe all the troubles that could occur, we can give common reasons for equipment failures. Of course, you cannot learn to repair the equipment by merely reading words that describe the troubles. Through practice you learn how to clean and adjust relays and make repairs.

The methods that we describe may not be identical to the method which you will use, or have used, but they will be similar. All telephone systems have similar electrical circuits; thus, comparable methods are used with all systems.

From this introduction to key system troubles, you should build toward a thorough understanding of the system. Much of this understanding is gained through your doing the work.

4-1. Operational Test of Key Telephone Systems

Some people may regard a key system as just another telephone system with a number of extensions. We, of course, after tracing through the circuits and discussing cabling and interconnections, know that beneath the simple surface appearance lies a rather complex system of relays, contacts, lamps, and wiring. Because of this complexity, our operational checkout should be complete. Every telephone in the key system is an individual unit, independent of the others; therefore, each unit must be carefully checked before we consider the installation completed. It is not enough to pick up only one instrument and test the hold, incoming signal, dial, and intercom features and assume that the system is in order.

645. Identify example telephone instrument operational and trouble symptoms and a possible trouble.

Not only must each phone be checked to see if it will permit talking, receiving, and dialing, but each phone must also be checked to see if it will hold the line; if it will control the line by lighting the busy lamp at all stations; if it will operate through the dial and the intercom; and, most important, if it will do all or any one of these things while other instruments are detached from the line. Each instrument or station must be independently able to pick up all lines, release all lines, pick up the intercom and dial a station, hold each central office line, or perform any other operation that it is supposed to while all other instruments in the system are hung up. Until each complete system is checked out carefully, you cannot be sure that it is properly installed.

You will realize after having worked with a key telephone system that the results are sometimes unusual because of the common connections. For instance, sometimes all lamps may come on at once but each will burn dimly. Or in another situation, all lamps light one at a time and flash although only one incoming call was originated.

The ground connection for the system is very important and should be rechecked as part of the checkout. If the ground is not good, it can cause a great deal of grief. If the ground wire is broken, the trouble indications are unusual. For instance, a broken ground wire in a 1A2 system may result in burned-out transistors of the 400D KTU. From these trouble symptoms you should realize that each system has specific symptoms that occur with an open ground. Other systems may have other symptoms. Be sure that the ground for your system is solid and is protected from damage. If a ground rod is used, make sure that it is driven deeply enough to give a good ground and that it is located in a place where it will not be damaged by grass cutting tools, thus cutting you out of service. Some 1A1 key telephone systems signal just like a selective ringing system—ring to ground (also referred to as "common audible"). All ringing is through ground return to the central office. The system, with the 230B KTU circuit, usually uses metallic ringing (ring to tip or tip to ring signaling).

The preceding troubles are just a sample of the troubles that can show up on individual sets or parts of the system. There are many troubles in a 1A1 key system that may affect only one telephone. This is the reason we say that key system telephones are not extensions but are independent of each other. Before you announce that a system is ready for use, be very sure that you have checked each phone and every feature. These tests are made with no other instrument off the hook.

Exercises (645):

1. Identify three typical signaling symptoms for an instrument operational check.

2. Give a supervisory operational symptom for a key set.

3. State two additional operational symptoms to monitor.

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4. What is an instrument relationship to note during an operational check?

5. List three probable lamp trouble symptoms.

6. Identify a typical result from a circuit fault.

7. Give an example key system fault.

646. Given specific operational checks for a 1A1 key system, cite a symptom to be noted for each.

In the following operational tests you will have a limited need for an assistant. Check the system operation by using the following procedures:

a. Plug in the power unit cord.

NOTE: If at any time you do not get the indication of proper operation, trace your wiring. Troubles in a new installation are most often the result of wire or connection defects, not faulty telephones or equipment.

b. With all other telephones "hung up," lift your telephone handset, press each PICKUP button on the first telephone of the system and look for the constant glow of the light under each depressed pushbutton. In addition, dial tone should be heard from each CO line.

c. Determine if the first incoming line can be held by depressing the first PICKUP key and then depressing the HOLD button. The first PICKUP key should be restored by the depressed HOLD pushbutton as the latter button returns to its normal position. Also, the lamp under the first PICKUP key should momentarily go out before lighting again. Its second lighting period is the result of an operated H relay. Of course, if the system includes the winking circuit option, then the lamp will wink while the H relay is operated.

d. Release the H relay by depressing the first PICKUP key. Again the lamp under the pushbutton will go out and then reoperate.

e. Dial the central office number of the second line. Now, you should hear ringing and should see the lamp flash under pushbutton 2. Furthermore, the lamp under pushbutton 1 for your station should also be lighted, but steadily.

f. Answer the ringing signal by depressing the second PICKUP key. The lamp under the pushbutton for the second line at your station should change from flashing to steady. The depressed second key restores PICKUP key 1. Lamp 1 must go out.

g. Return to the first line by depressing PICKUP key 1 again.

h. Dial the central office number for the third incoming line. Again, you should hear ringing and should see the lamp under pushbutton 3 flash. Answer the signal by depressing the third PICKUP button.

i. Follow the same procedure for checking signaling of all additional incoming lines.

j. Advance to PICKUP key 2 and press it. Then dial the central office number of incoming line 1. As a result, the lamp for line 1 should flash.

k. Press the PICKUP key for line 1. Note that lamp 1 should light steadily and lamp 2 will go out following restoration of the second pushbutton.

l. Press PICKUP key 2 and then the HOLD button. Accordingly, lamp 2 will light, go out, and light again, if the H relay for line circuit 2 operates properly. Lamp 1 will go out.

m. Press PICKUP key 2 to release the H relay.

n. Press PICKUP key 3. Look for a lighted lamp and listen for dial tone. Rotate the dial once and note that dial tone ceases.

o. Press the HOLD button and observe the lamp for PICKUP key 3. Again, it should temporily go out during the transfer to the H relay from relay A.

p. Depress PICKUP key 3 again.

q. Repeat the procedures n through p while operating the remaining PICKUP keys. (If you are testing a system with more than four PICKUP keys, then use these steps for the additional keys.)

r. Depress the INTERCOM pushbutton and dial "2." As a result, the ringer at the telephone you are using should ring. If you were operating a station other than station 1, then you would dial that code to ring the bell. The ringer operates only once. The lamp for the INTERCOM button glows steadily as long as the pushbutton is depressed.

s. To determine the quality of your talking circuit, dial the intercom number for the station where your assistant is located. Following his or her lifting of the station handset and pressing the INTERCOM button, you should converse. Ask this person to listen for the intercom signals for the remaining stations when you dial them. Also, ask your assistant to notify you if anything appears irregular.

t. Dial each of the intercom code assignments and wait approximately 1 minute for a return call, in case of an irregularity.

u. Return your handset to the telephone when you think your operational test of this station is completed.

v. Walk to station 2 and repeat the operational test described in steps *b* through *q*. During the test of the intercom from station 2, you dial the assigned number for that station.

w. Perform this operational test for each of the stations in your key system.

If exclusion is used, operate the EXCLUSION key after lifting the handset and depressing the first pushbutton at the exclusion station. Then go to a station that is to be excluded and press the first pushbutton and lift the handset. At this excluded station you should have complete silence: no dial tone, no side tone, etc, when the EXCLUSION key is operated.

We have used one procedure for testing the operation of a newly installed 1A1 key system. You may want to use a procedure that differs from our description. Just remember, use a method that is effective. It must result in checking each circuit and each line at every station. You need not dial the complete assigned number for all called stations of your system when testing an existing system. Dial only one digit and determine if the dial action breaks dial tone. This performance eliminates your signaling an occupied station unnecessarily.

Exercises (646):

1. Having lifted the handset and while depressing the four PICKUP keys serving CO lines, give two symptoms that should be noted if the circuits are good.

2. Having lifted the handset and depressed the second PICKUP key, indicate two operational symptoms that should be noted following depression of the HOLD key.

3. What operational symptoms are to be noted at a PICKUP key receiving incoming ringing current?

4. Identify an operational symptom to be noted when you depress the pushbutton having a flashing lamp.

5. Having lifted the handset and pressed the INTERCOM pushbutton, what operational symptom is evident?

6. Having lifted the handset, pressed the INTERCOM pushbutton and dialed the local intercom number, give two operational symptoms to be noted.

647. Compare 1A2 key system operational symptoms to those of the 1A1 key system.

Your operational check of a 1A2 key system should give like test results to those noted with the 1A1 key system and should be done in the same manner as was described in the preceding paragraphs.

The operational test will reveal that the features for one are observable on all others. These results are due to the key system telephones being connected in parallel. The operation of the hold circuit relay is checked by pressing first the PICKUP key and then pressing the HOLD pushbutton. In this case the lamp under the PICKUP key should either wink or glow steadily, after momentarily being extinguished. It is evident, however, that you cannot determine the quality of the talking circuit without having an assistant. Remember: All telephone handsets except the one at the station where you are testing must be hung up during an operational test. Use the connection table (cutsheet) to determine the intercom dialing code.

Exercises (647):

1. Give the operational symptom similarities for a depressed HOLD key on 1A1 and 1A2 key systems.

2. Compare the EXCLUSION key operational results for the 1A1 and 1A2 key systems.

3. *How do you determine the quality* of the talking circuit for the 1A1 and 1A2 key systems?

648. Cite procedures to be taken when checking the operation of a 6A key system and note symptoms that indicate a proper condition.

Since the equipment used to provide the 6A communications includes circuits that are more complex, it is obvious that your operational checks are going to be more difficult than those using only the 207C intercom. You must also check every feature of the system at every station. Each station having a connection to a 6A system has greater independence than it would have if connected only to the 1A1 and 207C. Therefore, a trouble at one station may have no effect on the other stations. An example of this independence is illustrated with the "two-talk link" feature. In this circumstance, when all stations are idle and you depress the PICKUP pushbutton, all lamps operate for that line. This function is the same as that used with the intercom circuit of the 1A1 or 1A2 key system. Now you dial the intercom number of the desired station and, as a result, the line lamp for the selected station flashes and the ringer operates. Yet, the lamps for the intercom circuit at the other stations remain lighted but without the flashing. When the handset is lifted and the PICKUP button pressed at the signaled station, the lamp ceases flashing and the ringer stops. In addition, the lighted lamps at all stations, except the two connected for communicating, go out. You can see, therefore, the reason for saying: "It is most important that every telephone of a 6A system be checked for every feature."

Let us consider additional operating checks used with the 6A key system, and the indications that denote normal operation. (NOTE: To do these tests, you must have assistants at other stations.)

An earlier paragraph described the procedure for connecting to the selected station. You should remember that the first talking circuit connection operates the TB1 relay, which in turn operates TB2 of the secondary link. To advance our operational test a step further, you now talk with the assistant who answers the selected telephone and ask him or her to stand by while you get another assistant to dial the fourth station. This conversation is possible because of the operated TB2 relay. The third and fourth participants follow the prescribed procedure for making the connection. They should then be able to talk without interfering in your conversation with the first assistant, because their talking circuit is completed through the windings of the operated TB1 relay.

Since both talking circuits are busy, you should now determine if "camp-on" is possible. You do this by dialing the number of the station occupied by your third assistant. As a result, a busy tone should be returned to your handset receiver. With this response, have your assistants hang up. Immediately, the station ringer for the third assistant should operate and the associated lamp should flash. Hence, the camp-on feature is effective for your station.

NOTE: The key system features, for instance camp-on, may be constructed in a number of ways to give slightly different indications. We are not describing each. When you receive your assignment to the Air Force organization, learn what indications to expect with your system and then look for them during future tests.

You determine if the preset conference circuit is usable by dialing the assigned number. The called stations and the calling station lamps will flash and the ringer at the called stations operates. Your assistants lift the handsets and depress the buttons showing the flashing lamp at their respective stations. As a result, the ringer stops and the lamp changes to a steady glow. Remember: The lamp at the calling station flashes until the last conference station attendant answers the signal. Now all lamps should light steadily, and conversation should be possible between all conference members. To learn if a busy station causes the system to return a busy signal, request that one assistant hold his or her handset off the cradle and keep the INTERCOM pushbutton depressed after the other handsets are returned to the cradle. Then you dial the code number for his or her station again. Your station will receive a busy signal until the assistant restores the handset to the telephone cradle.

Other checks of the 6A key system are comparable to what we have described; therefore we won't emphasize them. For example, you have single-digit and two-digit seizure to test and may have preset conference codes of one and two digits. We repeat: you must test each feature at each station before you consider the installation complete.

During your operational testing, observe the responses of the telephone units closely. The dial and the pushbuttons should move freely. Of course, the Call Director has a greater number of buttons to check, but they function the same as the keys on the 560 series telephone. Each telephone, we have learned, must show the proper indications when a call is incoming and must permit good quality transmission when the talking circuits are complete.

Exercises (648):

1. List three operational checks to perform for a 6A system that are not done at the 1A1 and 1A2 systems.

2. Tell the lamp indication that follows your dialing of an intercom number in a 6A key system.

3. State the results of having selected and dialed a 6A intercom station and the attendant's lifting the handset and depressing the local PICKUP key.

4. What indication discloses that both talk-links are effective?

5. Give the operational symptom that indicates your desired station is connected for camp-on selection.

6. What operational symptoms follow the dialing of the preset conference number?

7. Give the lamp indications that accompany the answering procedure at the preset conference stations.

8. State a symptom that is indicative that the mechanical quality of the keys and dial is adequate.

649. Review two telephone set operational checks and note characteristics to look for at specified components.

You saw operational checks for telephone sets previously and should recall the transmission and signaling tests that reveal circuit quality and the equipment condition. Since a keyset is a telephone set, it is evident that the same operational checks noted for the regular telephone apply to these sets.

The transmission test consists of listening for dial tone, sidetone, and abnormal sounds, such as dial clicks during dialing, bell tapping, and scratching and sizzling, while conversing. Of course, the normal characteristic to expect is a good quality conversation—good volume and clear words.

The signaling test may be looked at as consisting of two parts—signaling out and signaling in. The outgoing signaling consists of hearing the dial tone, dialing a number, and getting the desired station. Of course, with the keyset, you have lamps that indicate during this action but we noted those symptoms earlier. For the incoming signaling check, you note the sound of the bell. It should be a clear ring and have adequate volume. Further, you check the volume control to insure that it will change the bell volume.

Remember that while you're doing these tests, observe the mechanical action of the dial, the hookswitch, the keys, and the volume control. There should be no binding nor delay in operation. Hence, you should not have to use force on any of the devices to activate them.

Exercises (649):

1. Identify two operational checks used to determine key system circuit quality and the status of the instrument's parts.

2. Name two dial symptoms to listen for during a check.

3. Reveal an abnormal sound for a receiver during a conversation.

4. If the trouble report is "Gets wrong numbers while dialing," what type check will you use to verify the report?

5. With a keyset, give two indicators to observe during a "signaling in" check.

4-2. Isolating Equipment Faults

Excessive current in an electrical circuit is often identified by a blown fuse or an operated circuit breaker. Not all circuit troubles are so readily identified as those in circuits having fuses. Because of the multiplicity of circuit connections, a key system trouble is often difficult to determine.

650. Given a typical keyset operation, identify an example trouble symptom and common procedures for isolating the fault.

Since it is common practice to leave one pushbutton in the operated position, a lifted handset is the most common reason for that PUSHBUTTON lamp to light. However, any line or equipment short circuit or ground gives the same result as the receiver off the cradle. We realize then that the line, in effect, is made busy by such defects. Some telephone people refer to a line that is continuously busy as having a permanent signal condition because they have worked with equipment which has trouble lamps that remain lighted until the defect is removed. (NOTE: Key systems do not have trouble indicator lamps. To identify system circuit troubles, you must know the equipment, know what to look for, and how to use test equipment.)

Permanent troubles are generally found by analysis of circuits and by testing the circuits. The analysis rarely determines a specific component within the unit as being open or short-circuited, but you more often will isolate the fault to a particular unit. Testing with test devices enables you to determine the specific component. You may also see an intermittent (disappearing) open or short. This latter trouble is caused by a loose connection. A visual inspection may be the only method for finding the defect.

Exercises (650):

1. Identify an example trouble symptom for a keyset that stands idle (without having handset lifted and while the key is pressed down.)

2. List three tasks commonly used to isolate a telephone equipment fault.

651. Identify two circuit faults and tell the expected results from each.

Let us recall basic circuit principles that you know already. These basic principles apply when you analyze any key system circuit.

a. An open circuit has no current because the circuit opposition is infinite. Figure 4-1 is a simple circuit that has no current because the switch is open.

b. A shorted circuit has less than normal resistance and an increased current. Figure 4-2 illustrates the effect of a shorted resistor in a series-parallel circuit. Figure 4-2,A,shows that the normal circuit has .5 ampere, and figure 4-2,B, reveals that the shorted parallel circuit reduced the circuit resistance to 6 ohms. Consequently, the total current has increased to 1 ampere.

c. Figure 4-3 shows another circuit effect which you need to consider when recalling circuit principles. The normal total resistance for that circuit is 15 ohms. As a result of the open in the 75-ohm resistor the total resistance becomes 18.75 ohms.

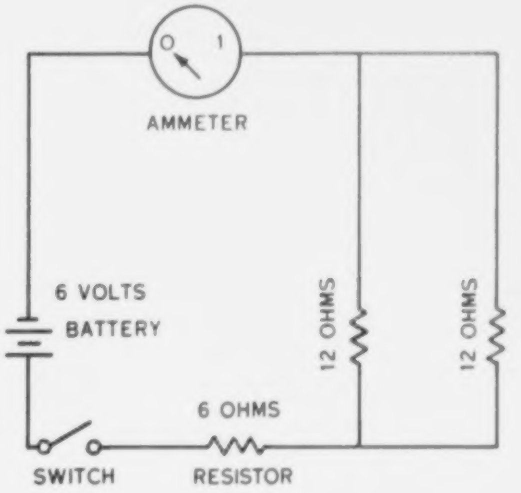


Figure 4-1. Nonoperating series electrical circuit.

Exercises (651):

1. Name the identified circuit faults.

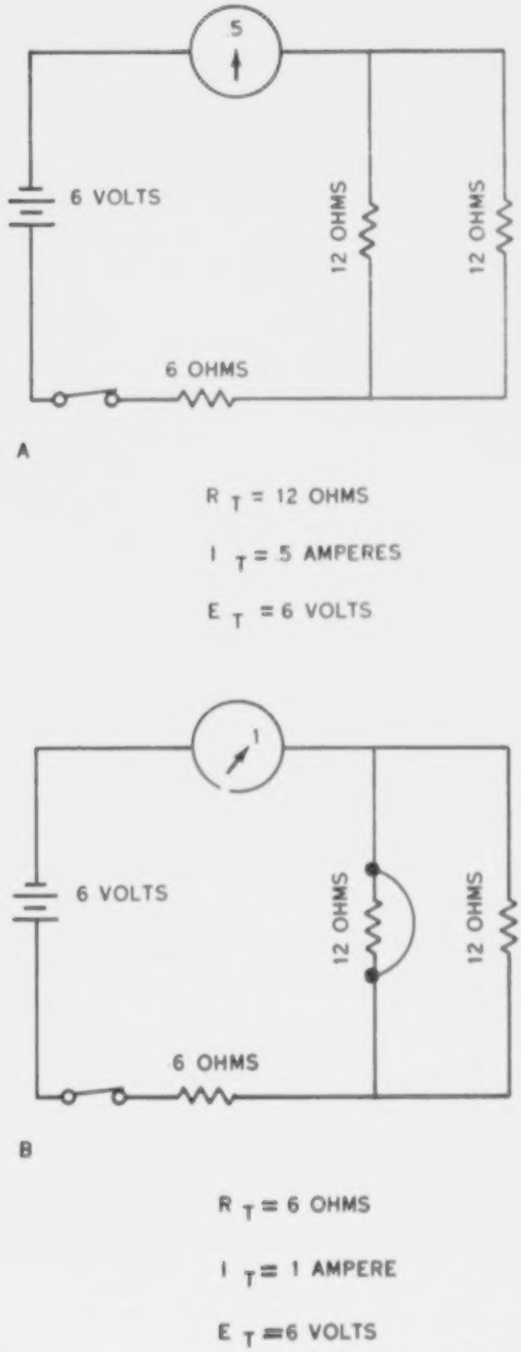


Figure 4-2. Normal and abnormal responses for a series-parallel circuit.

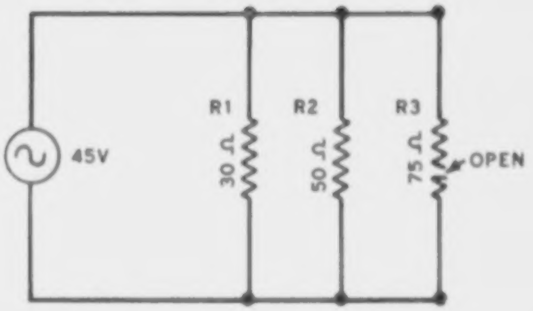


Figure 4-3. A defective parallel-connected electrical circuit.

2. What should be the expected result from a shorted circuit?

3. What circuit change should result from an open circuit?

652. Given a sample telephone trouble symptom, indicate a probable fault that would cause the symptom or disclose a reasoning for eliminating a suspect unit from consideration.

Although the circuits that we just analyzed are simple, the principles we used are applicable to complex circuits. Most key system defects result in more complex analysis procedures, as the following examples illustrate.

Assume that you have pressed the PICKUP key and then depressed the HOLD pushbutton but the associated lamp has not lighted. We need to consider whether the trouble is just the lamp, or whether it is relay failure. We know that relay A operates first, followed by relay H. Contacts of both operated relays complete the lamp circuit. You seldom have two relays fail simultaneously; therefore, we can assume that the lamp has failed. Replacement of the lamp should correct this trouble.

Assume that the hold relay was not remaining operated after being energized. Remember: You determine if the relay has operated by observing the lamp under the PICKUP key. What could be the cause for the H relay to restore? The H relay could have neither an open wire nor a short-circuited winding. A defective relay winding, either short-circuited or open, results in failure to operate. We know this to be true because an open winding prevents current, whereas a short circuit bypasses current around the winding. Yet the relay did operate temporarily. Open contacts as the result of a contact spring maladjustment are more likely to be the trouble cause. Open wires are more probable troubles than are shorted wires. However, relay maladjustments are more likely to occur than either of the wire faults.

Inability to dial could be another trouble symptom. You should understand that many faulty components can result in this symptom. For example, the telephone dial can be defective, the pulsing relay in the selector can be at fault, the companion relays of the pulsing relay can be maladjusted, or the rotary stepping switch in the selector circuit can be erring mechanically. Take a moment to think about this defect. If only one member of the system cannot dial, it is evident that the trouble would not be the selector or its relays and switch. Since there is only one selector KTU (207C) for the system, when its components fail to operate, all telephones in the intercom system are prevented from dialing or they will dial wrong numbers.

Likewise, if the ringing equipment is faulty, it affects more than one telephone station. Therefore, you may receive more than one trouble report of the same trouble. You may also receive more than one trouble report from the same subscriber. To illustrate, "bells don't ring," "no audible ringing," "don't answer," and "doesn't get calls" are possible reports that could be received from stations when the ringing equipment is not operating. Systems with lamps and bells for each station will seldom have all these reports returned because the lamps serve as backup signal indicators for the ringer.

"A conference station for a 6A key system does not answer" could be the trouble report. You learned that this equipment arrangement makes it possible for one originating station to call several other stations simultaneously. If all stations except one have answered, then the ringing equipment cannot be faulty. It is not probable that a soldered strap is going to become open, either. Possible troubles are faulty KTU connections or relay contacts which need burnishing or adjustment.

There are many trouble symptoms and isolating procedures that we have not discussed. To include all of them would require a chapter of unreasonable length. As you know, the equipment operates because of completed electrical circuits, and basic circuit principles are are applicable for all circuits. Perhaps the circuits are used somewhat differently or are constructed in a different manner, but you can easily determine these differences with time and study.

Exercises (652):

1. Having depressed the INTERCOM pushbutton and lifted the handset, the associate lamp fails to illuminate. What are probable faulty units for this trouble symptom?

2. If the intercom call of exercise 1 was completed and the conversation completed, what is the probable fault?

3. Assuming that the bell is ringing for an incoming call but there is no flashing lamp, what device is suspect?

4-3. Trouble Location in Key Telephone Systems

Key system troubles are brought to our attention by telephone users or by testmen. As a specialist you must then determine the specific location of the trouble. Effective troubleshooting results from good procedures, accurate thinking, and practice. Guessing and "inept or foolish fishing for troubles" usually lead to disastrous results. Think logically! If your car fails to stop following pressure on the brake pedal, you would not check the car radio.

653. Cite example procedures for troubleshooting telephone circuit faults and equipment that can be used.

Troubleshooting usually starts with an analysis of the telephone trouble report. Coordinate the trouble report with the schematic diagram for the equipment unit. Quite often you can isolate the fault to a particular component through this coordination. An operational check insures that the report is accurate and it often eliminates possible causes of the trouble, thus revealing the actual cause. Your trouble analysis should begin from the unit in trouble.

If the preceding actions reveal an open circuit, you can localize the trouble by placing a short circuit near the center of the circuit and by making electrical meter tests from both ends. The circuit end that does not indicate the short must have an open within it. Vice versa, if you determine the circuit has a short, then open the circuit near the center. Test toward the ends of the circuit from that open. The shorted end will be revealed by the test equipment. Remember: This described checking is going to be dependent on the type of circuit with which you are working. You do not short-circuit a live circuit because additional troubles would result. These testing activities are normally made in an isolated (disconnected) defective circuit. Test an idle or dead circuit with the ohmmeter or any other test device that has an internal power source. Some use a buzzer. Using one type of buzzer test set, you operate the buzzer when touching a wire that is good. Conversely, an open wire prevents the buzzer from operating.

Prior to the testing, monitor the circuit to make sure that it is a defective condition rather than a busy one. If you are to open an idle line for testing, notify the telephone users if possible. Do not keep lines and equipment under test any longer than is required for completing your testing. Therefore, have all your test tools and equipment available before beginning your tests.

Make certain that the trouble exists in your system equipment and not in the central office equipment or in the incoming line before attempting to test for troubles in the key equipment. After having localized the trouble, you should visually inspect the wiring and connections; then if your careful visual inspection fails to reveal the trouble, you may need to use metering type test equipment to pinpoint the defective component. By following the circuit while using a systematic process of elimination, you can usually find the fault in a minimum of time. This procedure eliminates in sequence the good circuit parts.

Exercises (653):

1. Identify two probable preliminary procedures for locating circuit troubles.

2. State two actions usable at the equipment for locating a fault.

3. Name two testing devices useful to a specialist in this career field.

4. What result often is to be noted when using a test unit to check an open circuit?

5. Name three probable trouble areas for a telephone keyset.

6. What is the most effective pattern for determining equipment troubles?

654. Analyze hypothetical situations to select possible procedures and their results for identifying a probable fault, and relate a typical repair for the fault.

You should understand that we cannot describe all troubles that you will experience and the procedures by which you determine the fault. We will list two defects and describe procedures that could disclose them. What we are showing may not be the simplest and most effective methods. But from this description you should see how to follow a systematic search of an electrical circuit. Develop your own method, and with practice you will learn how it can be improved.

Assume that the trouble report says that the user "can't dial" on incoming line 1. Again, you first make certain that the user of the set is not at fault because new personnel often mistakenly think the system is out of order when they do not fully understand the operating procedures. Thus, you should make an operational check to determine if the equipment is in fact malfunctioning.

Do not limit your dialing procedures to that one attempt after noting that the user's report was correct. Use the dial at that station and attempt to call a second station of the system. This action will show if the dial is at fault. For this problem, we are assuming that the second station is connected as normally expected; hence, the dial is all right. Stop for a minute and think about what else is indicative of a complete electrical circuit! What occurred when you lifted the handset and depressed the pushbutton for incoming line 1? Yes! You should receive dial tone, and the lamp for pushbutton 1 should illuminate. In our problem you did not receive dial tone but the lamp did illuminate.

Since the lamp operated, we realize that the A relay has operated. Analyzing the circuits of foldout 1, it is obvious that terminals 3 and 4 of terminal strip A are good. You will find these terminals to the right of relay A. They terminate the leads identified as A and A1. In addition, the adjoining orange-white and white-orange wires of the running and key cables, terminals 4 and 3 of connecting block 66E–25, the mounting cord leads A and A1, contacts of the line 1 PICKUP key, the hookswitch assembly contacts, and contacts of the HOLD button are good.

Further thought about line 1 results in our realizing that the trouble must be in tip or ring to the central office, or two sets of contacts of relay A, or tip (white-blue) and ring (blue-white) wires of the running or key cable, or terminals 1 or 2 of the 66A1–25 terminal or tip (white-blue) and ring (blue-white) wires of the mounting cord. Contacts of the PICKUP key for the first line, contacts of the cradle switch, the telephone network, the telephone transmitter, and the dial contacts were revealed to be good by the dialing action described a few paragraphs back.

What else can you do to isolate the trouble to a more specific location? You or your assistant could attempt to call the first incoming line from station 2. With a sucessful completion of a call from this second telephone it is evident that the trouble is not in the incoming cable that connects to terminals 7 and 8 on terminal strip A of the 230B KTU. We also can assume that the trouble is an open because if the fault were a short circuit, no call could be completed.

You have learned that relay contacts and mounting cords are suspicious points in a key system. For our purpose, we will take a jumper wire which has alligator clips at each end and place it from the No. 1 terminal of the connecting block to the 1T terminal of the 636A terminal strip (see FO 1). If you can now dial or receive dial tone from the first incoming line, you realize that the tip wire of the mounting cord was open. If you cannot receive dial tone or dial the first incoming line after installing the jumper, make the same type test of the ring wire. Connect the alligator clips to terminal 2 of the connecting block and terminal 1R of the 636A terminal strip. As a result of these tests, you will locate the trouble for this system which we are discussing. A conductor of the mounting cord was broken. Thus, you must substitute a good mounting cord for the one installed.

The trouble symptom of having no operating lamps is indicative of a possible power failure. Looking again at foldout 1 we see that to determine if the lamps have power we touch the test clips to terminals 10 and 9 of terminal strip on the 232B KTU. As a result of this touch, you hear a buzzing which indicates that the AC power source of the lamps is operating. You could next place the test set leads against terminals 26 and 4 of the A terminal strip for the 230B KTU. From this test you get no response; thus no battery potentials are available. We said earlier that the B battery source has a connection to two terminals. All devices requiring this battery potential are then connected to these two terminals. Foldout 1 identifies both terminals as B BAT and B GRD. It would be advisable, now, that we check the fuse for the B BAT circuit. This fuse is installed on the power unit.

Of course, an experienced worker would probably have checked the fuse before making any of these tests which we have described. We have taken a few minutes longer but have arrived at the same conclusion. As an apprentice you will be expected to take somewhat longer to solve the problems. Although you work slowly, be sure that your declared solution is correct, since repairing or replacing a unit that is not defective (because of a wrong decision) results in unnecessary costs.

Testing a circuit reveals the condition of its components. Thus, the components are not usually tested individually. For instance, we learned that by operating a PICKUP key we operated a lamp. Consequently, you should realize that relay A in the KTU and its associated contacts, which complete the lamp circuit, must be good. Also, the lamp is good and the power circuits for the lamps and relays are functioning. Periodic circuit testing is an effective method of keeping a telephone system in continuous operation. Tests are most effective when they are made according to an organized program. Your use of these tests allows detection of a substandard operation almost as soon as it appears or possibly before a unit fails.

Most telephone users have few complaints because of equipment failure. Credit for this equipment reliability goes to the manufacturer. But even the best and most expensive device will fail sometime during its years of use. When failure occurs, you must make repairs without delay. The personnel of your using organization will expect this because troubles in equipment cause them additional expense and work.

Exercises (654):

1. Point out three effective procedures for troubleshooting telephone equipment.

2. Assuming that the lamps for PICKUP keys 1, 2, and 4 at station 2 operate as expected but lamp 3 doesn't light, identify two probable reasons for the symptom.

3. Why would you not include the interrupter contacts for the assumed problem of exercise two?

4. Identify three quite probable faults in telephone equipment.

5. Give two effective equipment maintenance procedures used to limit outages.

4-4. Repairing Key System Equipment

You will find that just your regular maintenance of the equipment can cause a need for repair. To illustrate, each time a cover is removed to make an inspection, dust can settle on the underlying devices. Also, every time you swing the equipment gate to observe or clean the terminals at the rear of the KTUs, the single-strand wires are flexed and bent. In time, therefore, some of these wires may break. Furthermore, personnel cleaning the area may cause trouble by letting scrubbing water splash on connecting blocks or soak cable runs. Maintenance performed carelessly causes more harm than good.

655. Review a major cause for telephone equipment troubles and typical maintenance actions used to restore the equipment.

Discounting the human element and assuming that all precautions were observed when the equipment was installed, there are few troubles because, with the exception of the rotary switch and the relays with their armatures and contacts, there are few moving parts in the equipment. Of course, the telephone has the PICKUP, HOLD, and CRADLE switches, in addition to the dial.

Lamps may burn out. A sudden overload may open a fuse. On extremely rare occasions a relay winding, resistor, or capacitor may become defective, but most of the actual equipment troubles will be caused by mechanical failures, for instance that of relay contacts.

Relay and Switch Maintenance. We know that you cannot become an expert in the care of relays and switches without making actual adjustments, but you can learn of the relay construction and can analyze the effects that a change in adjustment will have on the telephone circuit. Remember: Deviation from established values are to be expected. The manufacturer realized that the equipment adjustments would deteriorate following many operations, and allowed for the change. Accordingly, the manufacturer's specifications generally give two sets of tolerances: one set is referred to as the inspection (test) value and the other is called the readjust (or adjustment) value. The inspection values allow for equipment deterioration before any adjustment is necessary. When you think a circuit is defective because of a relay being out of adjustment, it will be necessary that you remove the relay from the circuit in order to make the electrical test while using a current-flow test set. But this procedure should be the final action that you take.

Exercises (655):

1. What is the equipment unit(s) that is (are) most apt to fail?

2. Identify the two test tolerances useful for determining the condition of telephone system relays.

3. Name equipment to use when testing relay specifications.

656. For relay adjustments, indicate typical measurement factors, and select adjustments from an example chart.

Relay Adjustment. You have learned that relay adjustment is divided into two major classifications:

electrical and mechanical. The electrical adjustment consists of applying current to the relay. This current is similar in value to that which the relay has under actual operating conditions. Use the test current requirement for this test. If the meter of the test set registers within the prescribed range, no further check is made. If the relay is found to be out of adjustment during the current requirement test, then the controls of the current-flow test set are repositioned to permit a check of the relay using the readjustment requirements. These readjust requirements are more critical; thus less tolerance is permitted in the relay adjustments. The mechanical adjustments are corrected so that the relay can meet its electrical requirements. The mechanical adjustment consists of spring gauging, tensioning, contact spacing and alignment, and aligning the mechanical parts of the relay. Normally, an electrically readjusted relay will hold its adjustment for a considerable length of time.

Electrical requirements cannot be met without the relay having the proper mechanical adjustments. To illustrate the meaning of the preceding statement, look at figure 4-4 and consider the statements which follow. You can see with this simple representative A relay that two circuits are under the control of the A relay circuit. Since switch S1 is closed, relay A has operated and it, in turn, operated relay Z and restored relay B. Assume, now, that the make-lever spring for relay A (the spring which has forced the attached contact to complete the Z relay circuit) is normally adjusted to a tension of 17 grams as read with a gram gauge and that the break-lever spring (the spring above relay A which opened the B relay circuit) is normally tensioned for 30 grams of pressure. With these spring tensions and with the normal conductor resistance in the operating circuit of relay A, the current in the A relay is 15 milliamps. Likewise, consider that the worker has inadvertently wiped the break-lever spring until the tension became 17 grams. Hence, the A relay operates with a reduced current; possibly 10 or fewer milliamps. With the reduced current, the relay operates prematurely. Consequently, relay Z operates before it should and relay B releases early. Think of relay A as being in the dialing circuit. How will its early operation affect the selection of a station? The result could be a wrong number. The two associate circuits are equally important; thus each must operate and release at the proper time.

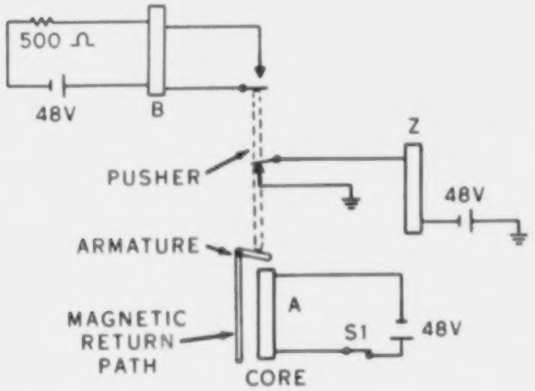


Figure 4-4. Simplified relay operating action, illustrated.

The contacts, which should mate, should have adequate space between them when they are open to insure no physical connection. Yet the space should not be so excessive that they cannot mate and then rub together (called contact follow) for an instant. This contact adjustment is not normally considered as critical as the spring tensioning or armature travel adjustments, since it has a direct bearing on one circuit only; whereas the other two adjustments could affect several springs and contacts, which in turn could affect their associated circuits. For the greatest possibility of accurate mating, the contacts should meet near the center, but the contact positioning shown in figure 4-5 is acceptable to most Air Force telephone system repair people.

Table 4-1 is an adjustment table which one manufacturer provided for their intercom KTU. You should have no trouble determining the requirements from this table because each column is identified. For example, the T relay has 815 ohms of resistance; its armature travel must be twenty-six thousandths of an inch, as checked with a relay feeler gauge; and the electrical test requirement is 15 milliamps of current to operate the relay. Similarly, when the current is reduced to 5.2 milliamps the relay must not operate. Furthermore, the current requirement for the readjustment test is 14.4 milliamps to operate relay T, and 5.4 milliamps should not operate the relay.

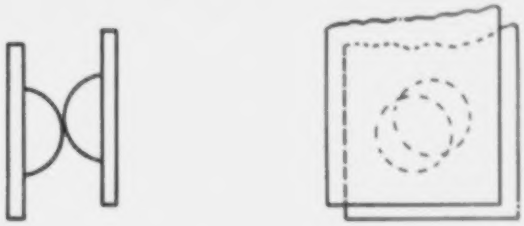
NOTE: If the time comes when you must adjust a relay, make sure that you use the adjustment table for your equipment because each manufacturer uses different specifications to accomplish the same purpose. You may never adjust your key system relays because they are reliable. For this reason, your organization may not be authorized a current-flow test set, without which you cannot make such adjustments.

Exercises (656):

1. Identify the two relay adjustments.

2. What are the electrical test values?

3. Give mechanical test adjustments.



CONTACTS MUST ALIGN WITHIN
1/3 OF THEIR BASE DIAMETER

Figure 4-5. Relay contact alignment.

TABLE 4-1
RELAY ADJUSTMENT REQUIREMENTS

		Mechanical Requirements				Direct Current in Amperes				
						Test		Readjust		
Relay Desig	Coil Resist	Contact Pressure	Arm. Travel	Resid Screw Height	Hold	Oper	Non-Oper	Oper	Non-Oper	Remarks
T	815		0.026			0.015	0.0052	0.0144	0.0034	
C	156		0.026		0.0249	0.0495	0.0213	0.0476	0.0222	1/16" sleeve
B	815		0.026			0.0157	0.0098	0.0151	0.0102	
A	60/60		0.022					0.019	0.016	Dial relay make on 0.007", break on 0.011". Test values same as readjust.

4. What is a likely relay fault if the mechanical tensioning is too heavy?

5. What is the typical minimum contact alignment for a telephone relay?

6. Give the term for the relay spring action that insures good contact mating.

7. Indicate the armature travel for the A relay of table 4-1.

8. What are the electrical readjust specifications for the B relay of table 4-1?

657. Compare relay and switch maintenance by citing similarities.

Switch Adjustment. The basic purpose of switch maintenance is also trouble prevention rather than trouble clearance. Thus, you inspect all elements of the switch at regularly scheduled periods. This inspection may often consist of a visual check only. If a switch appears to be operating improperly, adjustment may be required to restore it to full operation. We repeat, however, that you do not readjust any switch unless it is definitely at fault and must be tested electrically. You should realize from this former statement that the test of switches compares to the test for relays. Both units are tested electrically and adjusted mechanically. Since we described the relay test procedures and adjustment, we are not going into the details of switch adjustment.

Exercises (657):

1. Give the purpose for relay and switch maintenance.

2. How do the switch maintenance procedures compare with those of relay maintenance?

3. If relay and switch adjustments are required, what are the procedures involved for both?

658. Specify typical repair procedures for key system equipment and cable.

Key System Maintenance. We noted that most troubles are the result of moving elements. Therefore, broken wires in a cable are not often found. This is a good thing, because it is difficult to locate a broken wire in a cable. You could use either the jumper wire substitution method or the resistance test to identify the faulty conductor. The probable repair for a cable having a faulty wire or wires is to replace the cable.

We have said that the occasion may come where you need to replace a component because of a defective winding. With most systems, however, you will replace the KTU to restore the system to normal operation.

The 1A2 key system KTU replacement is simple when compared with the 1A1 KTU replacement. Each 1A2 KTU has contacts formed into a plug that you insert into a mating receptacle. To replace one that is defective, you remove the KTU from its connection with the mating receptacle and install the replacement KTU in place of the defective unit. The 1A1 KTU components are individually replaced when they become defective. The removal is difficult because you must use a soldering iron to disconnect wiring and must identify each wire so that it is put back to the correct terminal during the component replacement. It is easier to remove the component while the KTU is installed than to take the KTU from the cabinet and then remove the component. If you remove only the component, you can leave all the unit strapping and jumpering and remove only the wires that serve the defective device. However, you must use extreme care so that you don't damage other wiring.

Your knowledge of telephone station maintenance also applies to station equipment. Although each station has many mechanical devices, you will find that the repair is comparable to the telephone station maintenance described in Chapter 3.

Exercises (658):

1. What is the typical corrective maintenance for a key system?

2. Identify three units in a key system that are usually *Remove* and *Replace* (R-R) maintenance.

659. Give techniques used to connect wires on solderless terminals and specify approved standards for a termination.

You may be responsible for replacement of components that are installed without using solder. The wire is connected to the terminals of these components with a tool referred to as a "wire wrap gun."

Using a Wire Wrap Gun. In the situation where the component is defective, you remove the wrapped wire with an unwrapping tool. You should not reuse the twisted wire again because it will probably break during a rewrap. Furthermore, you cannot get the desired pressure of the good metal-to-metal contact again. You should cut the old wrap and use the slack in the wire or use a new length of wire. However, if you must use the old wrap, solder the connection after installing the wire again. The preferred method is that you install a new wire wrap around the component terminal.

You reveiwed the wire wrap gun, tool bit, and how a wire is inserted for wrapping a terminal in Volume 3, Chapter 1. You should also recall that although there are several methods for powering the tools, each unit causes the bit to rotate while the sleeve remains fixed during the tool operation.

A solderless connection made with a wire wrap gun will have the basic requirements for an electrical termination. They are: metal-to-metal contact, gastight, mechanical stability, a minimum of vibration strain and handling stress, and high-pressure contact. To illustrate, a wire wrap on a terminal has approximately 29,000 pounds of pressure per square inch. Additional advantages to wire wrap connections include: Work area is safe because there is no heat which can cause undesirable electrical connections following splashing or dripping. Also, the installation cost is reduced because you have no need for solder, and each connection usually takes less time (and therefore less money) to make than will a soldered connection.

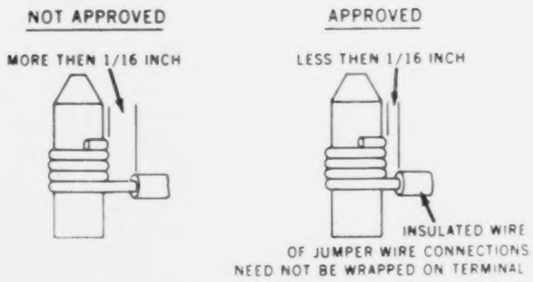


Figure 4–6. A solderless wrap, illustrated.

The length of the skinned wire is determined by the gauge of the wire. For example, 22-gauge wire should have 9/16 inches of insulation stripped from the wire. You must also have a minimum of skinned wire showing because the final appearance of the connection should have a maximum of 1/16 inch between the wire insulation and the terminal. Figure 4-6 illustrates an approved wrap showing less than 1/16-inch "shiner" between the terminal and the insulation. Figure 4-7 shows a properly completed solderless connection.

Having inserted the wire in the slot and bent it back within the sleeve notch, you place the tool over the terminal and pull the trigger. However, make sure that the terminal used is designed for wire wrap, that the terminal is tinned (cleaned thoroughly), that the wire remains fully inserted, and that you let the tool back away slightly during the operation. Also, you must insert the tool over the terminal a sufficient distance that will allow the proper number of turns to be made. Accordingly, you must provide five or more turns on the terminal when using 22-gauge wire. Figure 4-6 shows five turns of wire on the approved terminal connection and figure 4-7 shows six turns on the terminal.

When the wrapping procedure is completed and the trigger released, you remove the gun with care so that you don't bend, twist, or scrape the terminal. You will not damage the equipment if you withdraw from the terminal while holding the gun at the same angle as the terminal is positioned. Therefore, if the terminal rests with the tip up as shown in figure 4-6, you lift the gun straight up. If you have a terminal positioned at the horizontal angle, as pictured in figure 4-7, you are required to withdraw the gun straight back (toward the left).

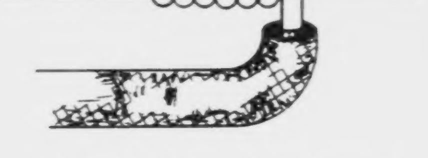


Figure 4–7. A completed solderless connection.

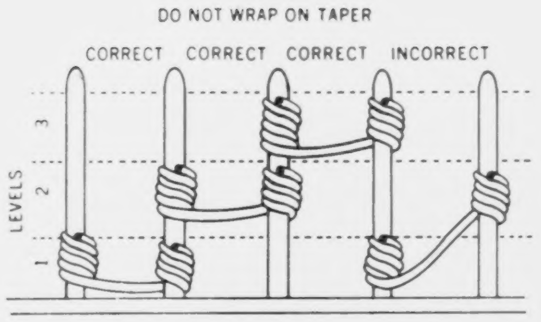

DO NOT WRAP ON TAPER
CORRECT
CORRECT
CORRECT
INCORRECT
LEVELS
1
2
3

Figure 4-8. Straps between solderless terminals.

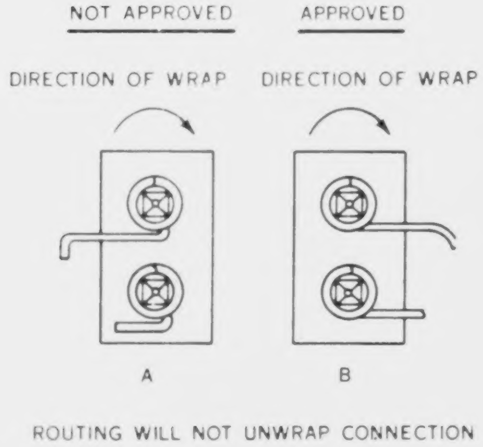

NOT APPROVED
APPROVED
DIRECTION OF WRAP
DIRECTION OF WRAP
A
B
ROUTING WILL NOT UNWRAP CONNECTION

Figure 4-9. Wrapping solderless terminals.

In addition to having the wire requirement of 1/16 inch from the terminal and the minimum number of turns, you also have several other rules to observe. Figure 4-8 presents three. There are three levels to each terminal. You make the first attachment at level 1 and close to the base, and continue your wrapping at level 2, then you use level 3. Furthermore, you must form all straps at the same level. Note too that you must leave some slack when strapping terminals. The instructions above the terminals of figure 4-8 show that you must never wrap at the very tip of the terminal because it tapers, thus will prevent your making a quality connection. Wrap the wire on the terminal in a manner that will prevent its being unwrapped during your further routing of the wire. Figure 4-9 may help you visualize this procedure. The connection of 4-9, B, shows that the wrapping direction is clockwise and the wire routing continues to the right of the terminal. The wire of A in figure 4-9 implies that you are routing it to the left after having used a clockwise wrap.

When wrapping two or more levels on the same terminal, you must never overlap any turn. Of course, you also must never overlap any wire turns with the single wrap either. Figure 4-10 illustrates this requirement for terminals having single and double connections. To prevent an undesirable connection (short) between two terminals, make sure that you remove excessive pigtail from the last turn. Figure 4-11 shows 1/64 of an inch of space between the pigtail of the left terminal and the wrap on the right-hand terminal. Figure 4-12 illustrates the spacing requirement between turns. Hence, the maximum gap is the diameter of one wire. It is evident in figure 4-12, A, that the total gap must not exceed the diameter of the wire; whereas the spaces in figure 4-12, B, total less than the diameter of the wire. If the gap is excessive, remove the wrap, cut off the twisted section of the wire, and make a new wrap.

Exercises (659):

1. How is wire germinated at a solderless terminal?

2. Explain the wire wrapping procedure.

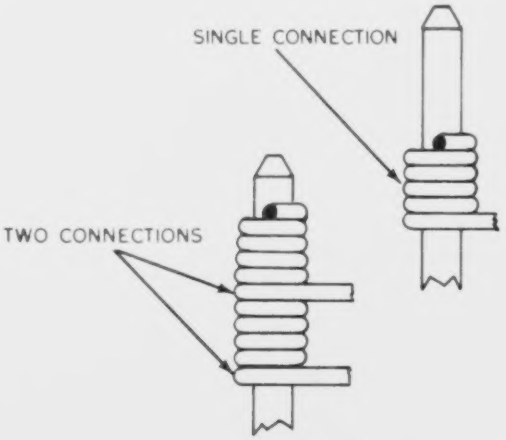

SINGLE CONNECTION
TWO CONNECTIONS

Figure 4-10. Single and double solderless wraps.

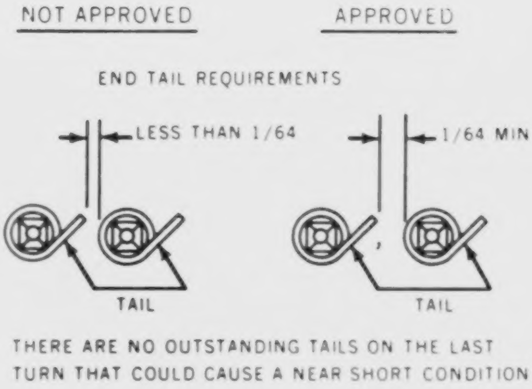

NOT APPROVED
APPROVED
END TAIL REQUIREMENTS
LESS THAN 1/64
1/64 MIN
TAIL
TAIL
THERE ARE NO OUTSTANDING TAILS ON THE LAST
TURN THAT COULD CAUSE A NEAR SHORT CONDITION

Figure 4-11. Approved spacing between two wrapped terminals.

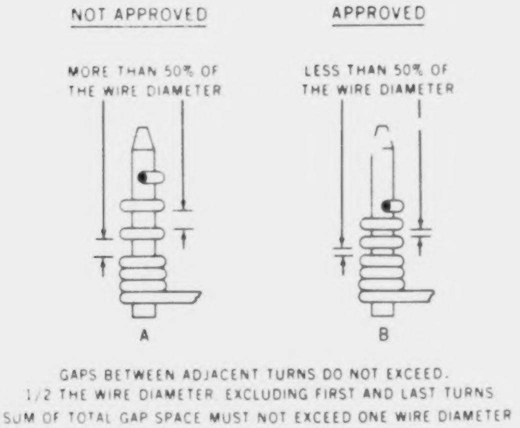

NOT APPROVED
APPROVED
MORE THAN 50% OF THE WIRE DIAMETER
LESS THAN 50% OF THE WIRE DIAMETER
A
B
GAPS BETWEEN ADJACENT TURNS DO NOT EXCEED.
1/2 THE WIRE DIAMETER EXCLUDING FIRST AND LAST TURNS
SUM OF TOTAL GAP SPACE MUST NOT EXCEED ONE WIRE DIAMETER

Figure 4–12. Turn spacing for solderless wraps.

3. Give four requirements for a solderless termination.

4. What is the maximum "shiner" at a solderless terminal?

5. Give the minimum number of turns for a solderless wire wrap.

6. Recall the three requirements illustrated in text figure 4-8.

7. State the directional requirement for a wire wrap.

8. Indicate the last three requirements for a wire wrap.

660. Specify typical wire replacement requirements.

Replacing Wiring. Past experience has proven that extra time spent in planning the details of wire replacement will result in greater accuracy in the connections and in a very neat installation.

If replacement straps are required between terminals, form them in the same manner as the one to be removed. Use care that you remove only the amount of insulation required because excessive bare wire can cause short circuits. Short, bare cross-connecting wires are permissible where there is no danger of short-circuiting with another circuit (see fig. 4-8). Otherwise, insulated straps (jumpers) of the proper length must be used. The method used to terminate the wire is determined by the terminal. If soldering is required, skin the insulation from the wire; clean the wire to insure a good connection before soldering.

Exercises (660):

1. Give a restriction for replacing straps between terminals.

2. If two common potential terminals that are separated by two unrelated terminals are to be strapped, what method of strapping is to be used?

661. Summarize the principles of maintenance and testing of key telephone systems.

We can summarize this chapter by saying that your troubleshooting procedure should consist of the operation of the equipment for verification of trouble, analysis of circuits to isolate the unit in trouble, visual inspection of apparent defective units, a point-to-point check using test equipment, and after replacement or repair of unit, you again operate the equipment. Remember: Communications equipment functions best when it is not "manhandled." In other words, do not touch any part of the equipment unless the system is definitely failing to perform the service expected. When operational tests disclose a definite need for corrective maintenance, think, and then locate the trouble location and repair in a systematic manner.

Exercises (661):

1. How do you verify the trouble report?

2. What should result from an analysis of the equipment circuits?

3. What two actions follow the trouble verification and isolation steps?

4. Tell two most important actions of a repair specialist.

CHAPTER 5

Maintenance of the 302 Switching Unit

PRINCIPLES OF operation and maintenance described in the previous chapters also apply to the 302 Switching Unit. To illustrate, the depression of a key completes an electrical circuit to a relay. The relay, in turn, completes additional circuits to lamps and relays. A telephone system functions because of these devices.

The functions and many of the devices of the 302 Switching Unit are, of course, somewhat different from those described previously. Also, this equipment includes a greater number of devices. We will show diagrams containing these devices and compare them to those with which you are already familiar.

To be a fully qualified installation and repair specialist must understand electronic circuit principles, component nomenclature, and the equipment connecting methods for a 302 Telephone Switching Unit. This chapter provides information about each of these factors. However, not all the devices, nor circuits, nor troubles are described because, as has been said before, we are naturally limited in our space. Furthermore, radio equipment circuits are not your responsibility. Your study of this chapter, in conjunction with the companion diagrams, should prepare you for your work with the equipment and the technical orders. You should gain knowledge while doing the work.

5-1. System Function

The 302 Switching Unit provides signaling, supervision, and communications for an Air Force operations van, aircraft, base operations, the weather station, the ground control intercept (GCI) station, and a control tower by means of wire and radio circuits. Because of these applications, the functions of the system are listed as:

- Wire-line and radio communications. (Remember: You perform maintenance on lines and circuits that connect with radio equipment, but the radio equipment is not your maintenance responsibility.)
- Request and acknowledge signaling.

662. Identify controls for the wire-line and radio communications circuits and name functions or actions that result when they are operated.

Wire-line and Radio Communications Circuits. Wire-line and radio communications circuits permit voice communications over loudspeaker or telephone units. The wire circuits include a dial, push-type (nonlocking) keys, turn switches, relays, terminal boards, cable pairs, headsets, 106B loudspeakers, and telephones. A dial should indicate to you that there is a circuit to a central office or PBX line. In addition, there are station lines which permit automatic signaling from a telephone station. The radio communications circuits include a transmitter, radio equipment, and a loudspeaker. Most of the controls for the circuits are installed in the operations van.

Figure 5-1 illustrates controls for an assistant controller's shelf. It is evident from the identification of these units that some of the controls are familiar. For example, we have already discussed LINE PICKUP keys and lamps. We also described HOLD keys at that time. For each line in this equipment, there is a HOLD lamp that is separate from the LINE lamp. Figure 5-2 shows a partial view of the interior of an operations van. It is apparent that there are three assistant controller's positions. Therefore, although only one set of controls is shown in figure 5-1, there are three sets of the controls in a van. The controller's OFF-WIRE-RADIO keys may not be familiar controls. They are lever type keys which lock into the selected position. Since they permit the controllers in the van to change the talking path from wire circuits to radio circuits, or vice versa, these controls are often spoken of as transfer keys. Two keys are necessary because one serves the controller's position and the second is operated by the assistant controller. In addition, a position may be unattended. At this time, the transfer key for the unoccupied position must be selected to RADIO or OFF. Another unit, shown in figure 5-2, is one that we also are considering with the controls because without it the communications circuits could not function. This is J53033P-1. This is a jack box unit, which accepts the plugs of the head telephone set (headset).

Station line telephone communications are possible between all system locations having a telephone. Typical locations with a telephone set are the control tower, base operations, the weather observer station, and the GCI station. The telephones in some control towers are in the AN/GTC-28 telephone equipment. This equipment is described in Chapter 6. The GCI line provides two-way telephone communications between the operations van and GCI station or voice signaling from the GCI station to the operations van. Voice communications from the GCI activate the loudspeaker in the operations van unless one of the controllers or assistant controllers is, by chance, monitoring the line. An operated key disconnects the loudspeaker of the operations van while connecting the headset to the GCI line. The loudspeaker is centrally located so that it can be heard at each of the six positions. It is not shown in figure 5-2.

The FLASH AND RING pushbutton (see fig. 5-1) connects ringing current to the selected station line, whereas the RLS pushbutton disconnects the headset from this line.

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The telephone dial permits the associated station attendant to dial directly over a PBX or central office line. The number of lines is dependent on the type of equipment and organization. To illustrate, the shelf for the ground control approach (GCA) system pictured in figure 5-1 indicates the number of lines to be six. Other mobile radar approach control (RAPCON) systems may be larger than this one. Likewise, stationary RAPCON systems are larger.

Radio communications are possible from the tower when the operator operates a PUSH-TO-TALK switch for the transmitter at his or her position. The controller in the van places the transfer key in the RADIO position when speaking to an aircraft by means of radio circuits. The OFF position of the transfer key permits controller to listen to radio calls but prevents his or her voice from being transmitted.

Exercises (662):

1. Identify and locate the pushbutton to press when you wish to determine if the fourth line circuit lamp winks.

2. Identify and locate in bay 10 of figure 5-1 the two controls that enable the controller to change from wire to radio communications.

3. Tell the function that is provided by the OFF position of the OFF-WIRE-RADIO switch.

4. What results when the RLS pushbutton on the controller's shelf is pressed?

5. What controller's circuit is complete following operation of the PUSH-TO-TALK switch?

663. Identify signaling methods and devices of the request and acknowledgement signaling circuit.

Request and Acknowledgement Signaling Circuit Operation. The visual and audible signaling is provided by the request and acknowledgment signaling circuits. The key and lamp units permit visual indications, while the loudspeakers and a chime are used for audible signaling. The controls and signal indicators for these circuits are located at the operations van and in the control tower. The operations van is identified as the "requesting station," and the control tower is referred to as the "acknowledgment unit." Three identical sets of controls and indicators are included in the operations van. Figure 5-3 reveals one set of controls and

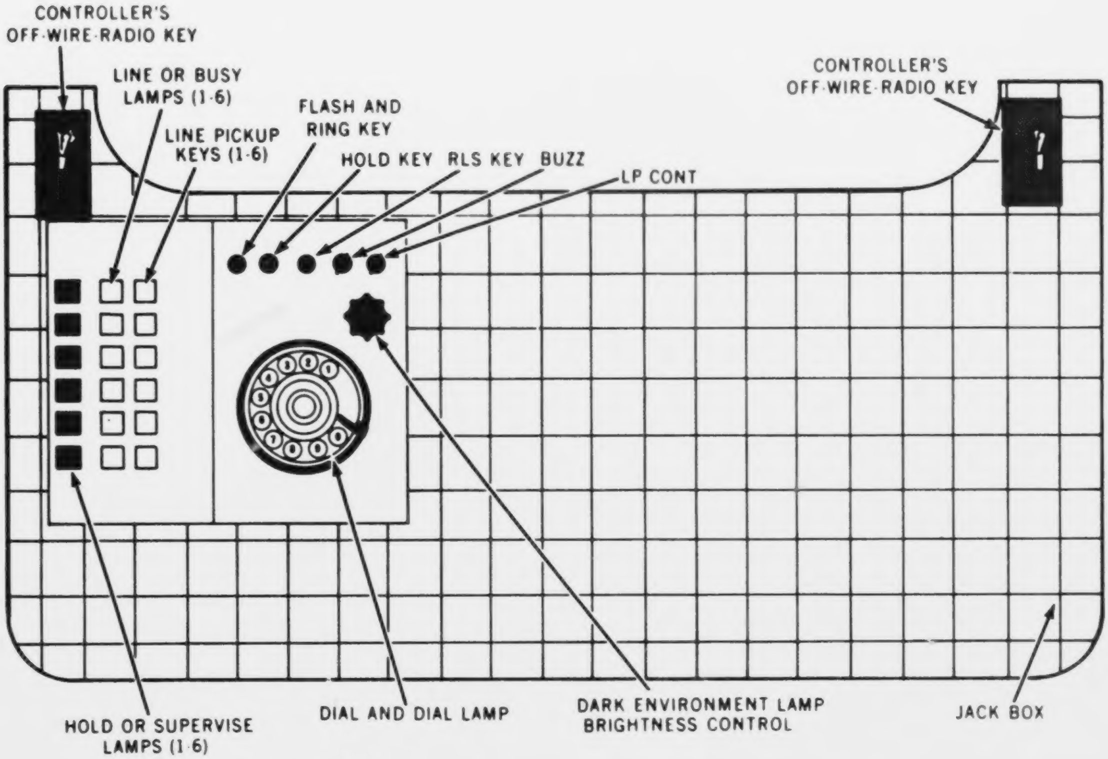
CONTROLLER'S OFF-WIRE-RADIO KEY
LINE OR BUSY LAMPS (1-6)
LINE PICKUP KEYS (1-6)
FLASH AND RING KEY
HOLD KEY
RLS KEY
BUZZ
LP CONT
CONTROLLER'S OFF-WIRE-RADIO KEY
HOLD OR SUPERVISE LAMPS (1-6)
DIAL AND DIAL LAMP
DARK ENVIRONMENT LAMP BRIGHTNESS CONTROL
JACK BOX

Figure 5–1. Wire-line communications controls for assistant controller's position.

indicators at the requesting station. Figure 5-2 also shows the equipment but identifies it with a J53033A–1. Also, you can see that the equipment is installed as a part of the controller's shelf in the operations van.

The operation of the colored pushbuttons and lamps results in identification of the various phases of an aircarft landing procedure. For example, depression of the WHITE key at the operations van results in flashing WHITE lamps and in operating a one-stroke chime at the control tower. The flashing WHITE lamps indicate to the controllers at the operations van and to the operators at the tower that a plane is a specific distance from the field during the landing approach. A tower operator acknowledges by pressing the WHITE pushbutton at his or her position, (see fig. 5-4). Thus, the lamps at the tower and van light steadily. When the radarscope (see fig. 5-2) indicates that the plane has arrived at a certain position, which is closer to the landing strip, the controller depresses the AMBER key. As a result, the WHITE lamps at the van and tower go out and the AMBER lamps at both stations flash. Again, the chime at the tower sounds once. The tower operator acknowledges by pressing an AMBER pushbutton. Hence, the associated AMBER lamps glow steadily.

With the arrival of the plane at a third designated position, as indicated by the radarscope, the controller presses the GREEN pushbutton. Again, the chime sounds and the associated GREEN lamps flash while the AMBER lamps become dark. The tower operator depresses the GREEN pushbutton to acknowledge. Now the GREEN lamps at each station change to a steady glow.

The RED pushbuttons operate in a manner opposite to that described for the three former keys. When the tower operator presses the key, the RED lamps flash. The controller acknowledges, in this case, by pressing the RED key on his or her shelf. Then the RED lamps cease flashing and glow steadily. The reason for installing the RED key so that the

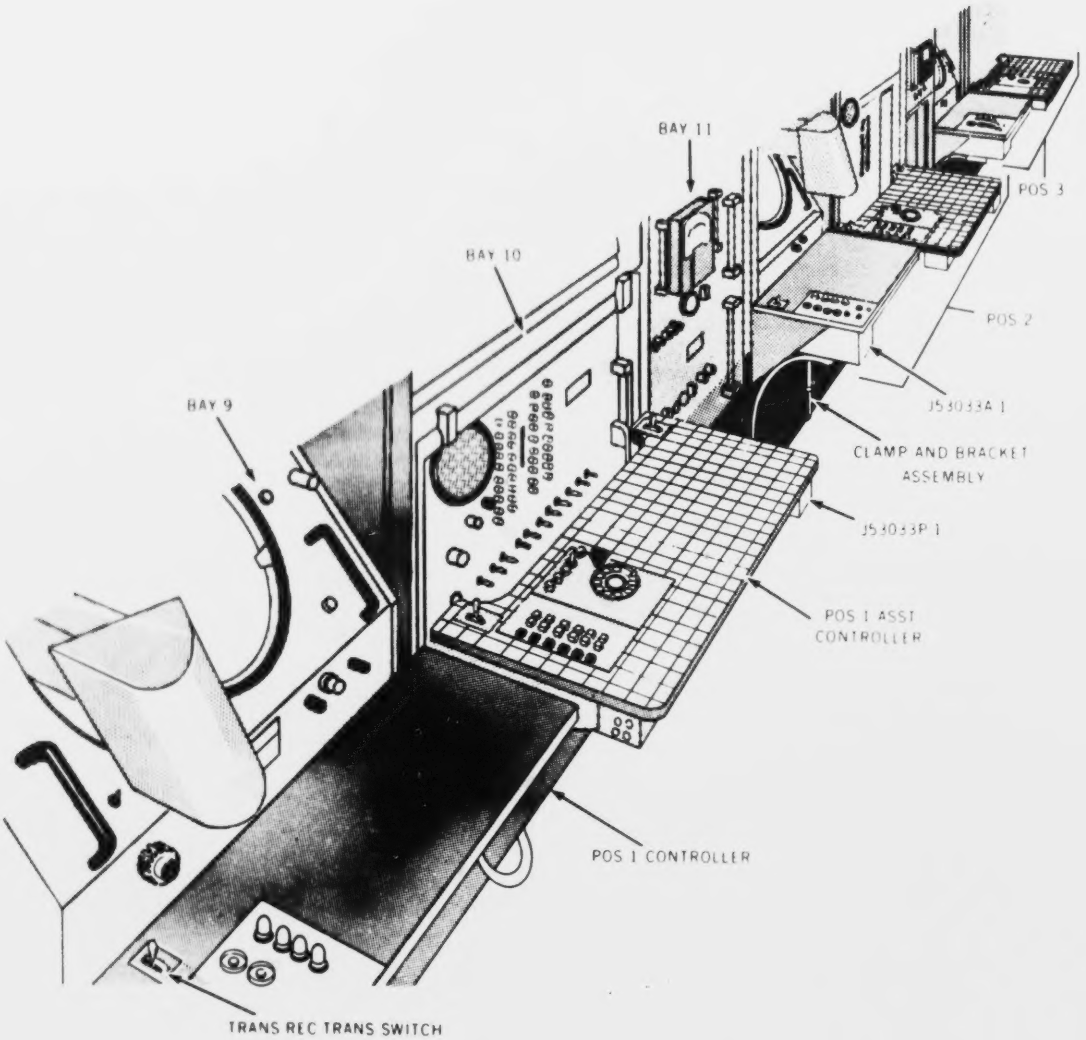

Figure 5–2. Position arrangment of operations van.

effects are opposite to the previously operated keys is that the tower operator must be able to alert the controller when there are conditions that do not permit a plane to land. Since red is symbolic of an emergency or requires a stop in the action, we can see the reason for using a RED key and lamp. The RED lamp is extinguished only by the tower operator; he or she presses the RED key for a second time to put out the lamp. Furthermore, while the RED key and lamp circuit are operated, the GREEN lamp is prevented from operating.

The WHITE, AMBER, and GREEN lamps can be extinguished also by depressing the associated key for the second time. However, the controller at the van must reoperate these keys to restore the lamps to normal.

Exercises (663):

1. Name the two signaling methods.

2. Identify the usual visual signal indicator.

3. What are the two audible signal indicators for the 302 equipment?

4. Give the 302 facility that is the "acknowledgment" station.

5. Normally what lamp indicates the farthest position out for an approaching aircraft?

6. What color is the emergency approach lamp?

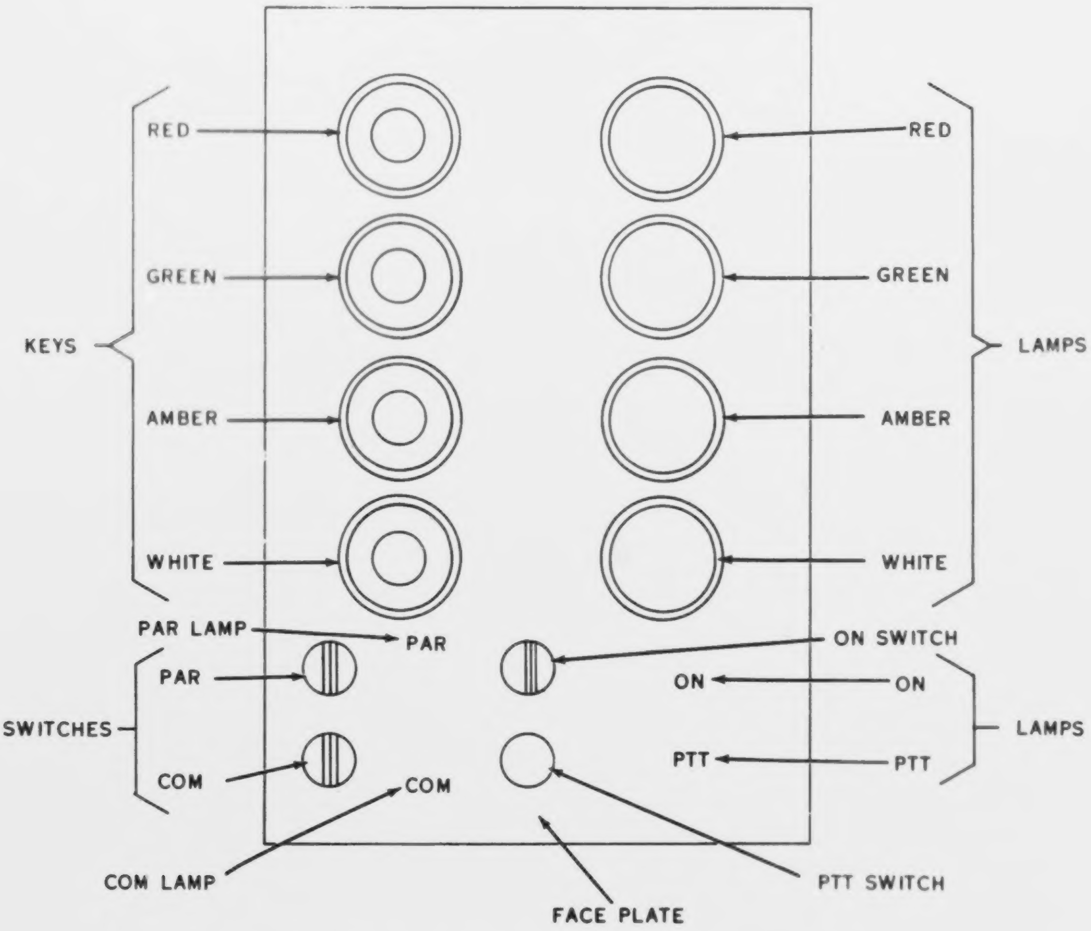
RED
GREEN
KEYS
AMBER
WHITE
RED
GREEN
LAMPS
AMBER
WHITE
PAR LAMP
PAR
ON SWITCH
PAR
ON
ON
SWITCHES
LAMPS
COM
PTT
PTT
COM
COM LAMP
PTT SWITCH
FACE PLATE

Figure 5–3. Closeup view of control devices at controller's position (operations van).

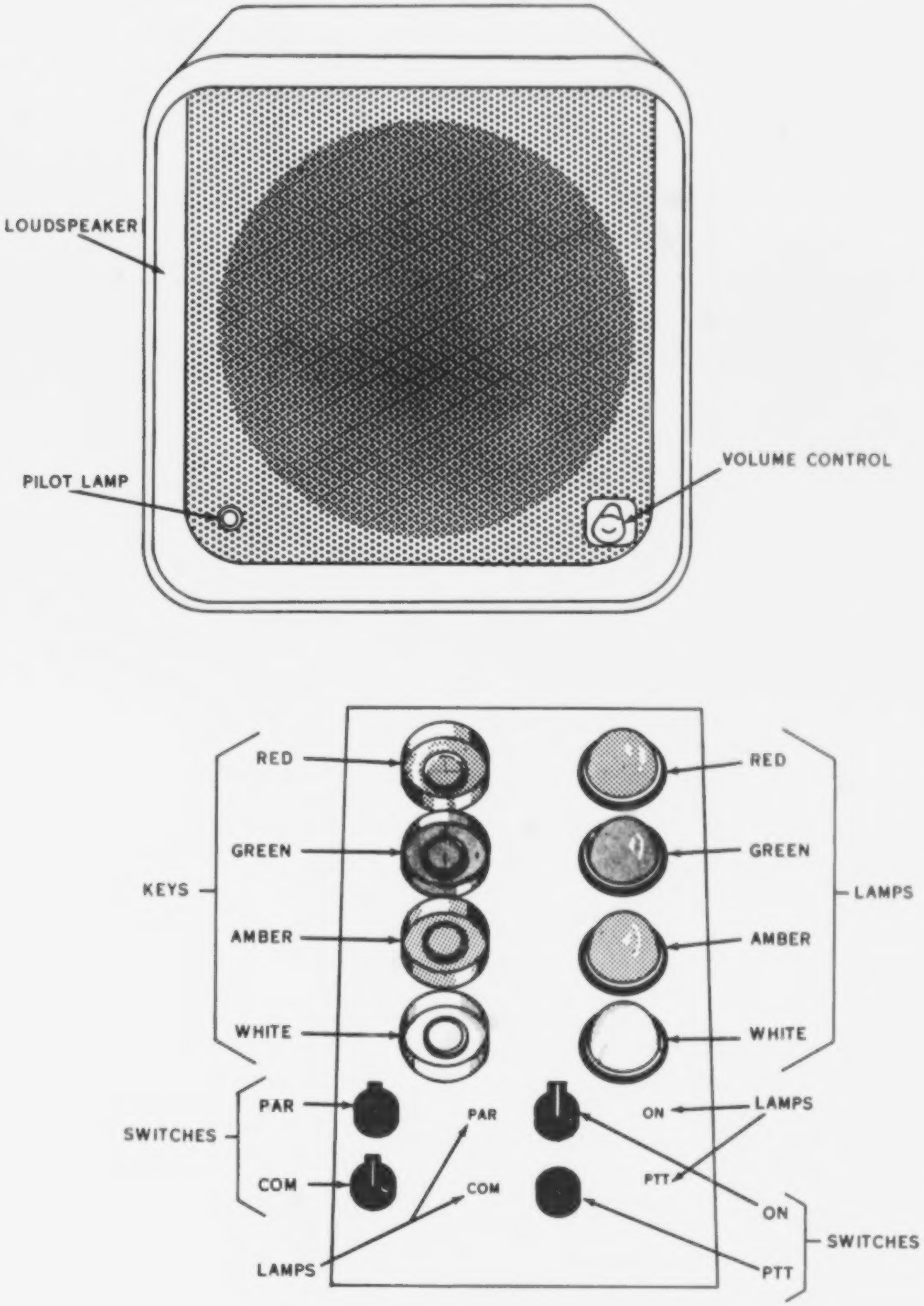
LOUDSPEAKER
PILOT LAMP
VOLUME CONTROL
RED
GREEN
AMBER
WHITE
KEYS
RED
GREEN
AMBER
WHITE
LAMPS
PAR
COM
SWITCHES
PAR
COM
LAMPS
ON
LAMPS
PTT
ON
PTT
SWITCHES

Figure 5–4. Typical operator's position in control tower.

664. Given controller's position controls, specify their functions or cite results of their operation.

Controller's Position Controls. Let us now consider the function of the other devices identified in figure 5-3. We have described visual signaling. Now we will talk about the audible communications. Although we included the loudspeakers and a chime as the audible communications devices, a hotline communications circuit includes many devices. For example, there must be switches for controlling the circuits. Two 2-position turn switches (PAR and COM) and the PTT nonlocking plunger key enable or disable these wire circuits. The voice circuits between the operations van and the control tower are one-way. The precision approach radar (PAR) voice circuit is one-way from the tower to the van. To precondition this circuit for talking, the tower operator turns the locking-type PAR switch. A lamp under the letters PAR illuminates the surrounding area of the panel because of the opaque material of which the panel is made. Thus, the circuit is identified as being ready for operation. This circuit is completed through transmitting equipment in the tower and headsets at the operations van positions. Each hand transmitter at the control tower is normally connected with the radio transmitting equipment. Operating the PAR switch, in conjunction with the PUSH-TO-TALK (PTT) switch, at the tower permits voice reception with any controller using the POWER switch at the associate position. Remember we said previously that the controller's transfer key allowed voice reception when placed in OFF or RADIO. The WIRE position also allows voice reception when the tower operator has pressed the PTT switch and when the tower operator and controller have both operated their PAR switches. The assistant controller receives the voice communications when his or her transfer key is in the same (WIRE or RADIO) position as the controller's or if the transfer key is in the RADIO or OFF position when the controller's transfer key is selected for OFF.

The one-way tower-to-van communications (COM) voice line is similar to the precision approach radar circuit. You first operate the COM switch to precondition the circuit and then the PTT switch to originate the call, and the controller or controllers operate the COM switch in the van to receive the communications. The assistant controllers would operate the transfer key in the same manner described in the last paragraph if they desire to receive the message. The operated COM switch likewise illuminates the letters COM of the controller equipment panel (see fig. 5-3).

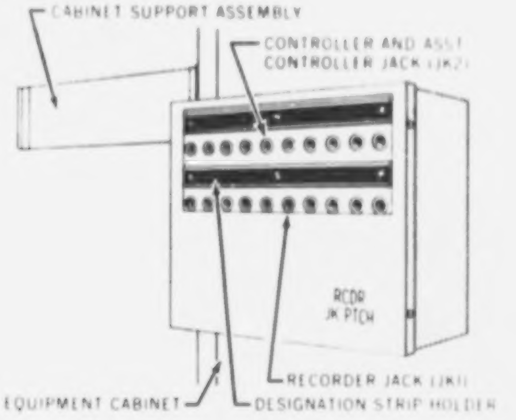

Figure 5-5. Patching panel for recording equipment.

The voice frequencies originating at the van are transmitted to the tower when the controller depresses the PTT key. In addition, he or she must place the transfer key in either the WIRE or RADIO position. The operated PTT key also results in lighting the lamp under the front panel and the letters PTT. At the tower, following the depression of the PTT key, the one-stroke chime is operated to alert the operator of the incoming call. (NOTE: This tower chime also operated following the depression of the colored keys on the controller's shelf.) A controller's position also has an audible device for alerting the controller, to warn him or her of an incoming call. The BUZZ turn switch, shown in figure 5-1, permits use of this buzzer or the silencing of it.

The ON switch (see fig. 5-3) must be turned to the ON position before any lamp (except the RED lamp) can operate. When operated, it also illuminates the area of the panel under the ON.

We noted that figure 5-3 shows one set of request and acknowledgment controls. Also, you learned that the operations van has three sets of these controls. The control tower also has two sets. In addition, the control tower has a loudspeaker common to each position. Figure 5-4 illustrates a typical control tower position. The speaker includes a volume control for determining the intensity of the voice output and a pilot lamp, which indicates when power is being provided to the speaker.

Return to figure 5-1 and note the dark environment lamp brightness control. This variable resistor provides adjustment in the circuit resistance of the lamps. If you desire more light in the darkened van, turn this control until you get the lamp brilliance that you desire. However, this resistor is used in conjunction with the LP CONT OFF-ON switch.

The six positions of the operations van are usually assigned so that some of the controllers and assistant controllers receive the COM one-way calls and the remaining personnel receive the PAR one-way calls.

The PAR and COM switch originated one-way communications can be recorded. The PTT switch originated circuit (talk circuit of van) is not connected to the recorder. The recorder jack patch assembly shown in figure 5-5 provides this activity. To complete the connections between the individual doing the speaking and the recorder, you use patch cords. A patch cord connects between the recording instrument jack (JKI) and the controller's jack (attendant's circuit for the position).

Exercises (664):

1. Identify the circuit controlled by the PAR turn switch.

2. Give the function of the PTT switch at the control tower.

3. What result should be noted following operation of the COM switch?

4. Identify the devices affected by the ON switch at the controller's panel.

5. Increasing the resistance of the dark environment lamp at the controller's position results in what condition?

5-2. Principles of Operation

At a sporting event, you have seen people selling programs. The vendors often use expressions that mean essentially this: "You can't follow the action without knowing the people and the positions." We think that you will likewise need to know the components of this equipment and their position or location in order for you to follow the action (operation) of the circuits. Thus, we first describe equipment location. Then, we disclose some of the circuit operations.

665. Identify 302 switching equipment, interconnecting circuits, units in terms of location and configuration.

Equipment Location. You know that the relay equipment for a 1A1 key system is installed in an apparatus cabinet. Furthermore, this cabinet is normally installed so that there is limited distance between the key units and the associate telephones. The 302 Switching Unit also has an apparatus cabinet and a separation between the cabinet and the telephones.

There is additional separation between the operator's controls and the apparatus cabinet since these controls and the apparatus cabinet are not a part of the telephone. Figure 5-6 shows that the apparatus cabinet is in the control tower. Secondly, shows that there is a power van in addition to the operations van. The station telephones are connected with cable to the power van equipment cabinet, not to the apparatus cabinet. The maximum distance permitted between the two vans and the apparatus cabinet is 10 miles. The cable between the two vans is normally 40 feet long.

The apparatus cabinet (also listed as telephone relay rack) is not large enough to contain all the circuit equipment for the three positions of the operations van and the two positions in the control tower. Hence, in the power van you will find equipment serving the positions of the operations van. Figure 5-7 reveals the placement of components for three positions. The numbers J53009CW-2 and J53009CY-1 identify the specific equipment units. To illustrate, J53009CW-2 is a unit that includes relays C1, CT, TR, WT1, TB1, and TB2, as well as other devices. J53009CY-1 includes relays WT2,

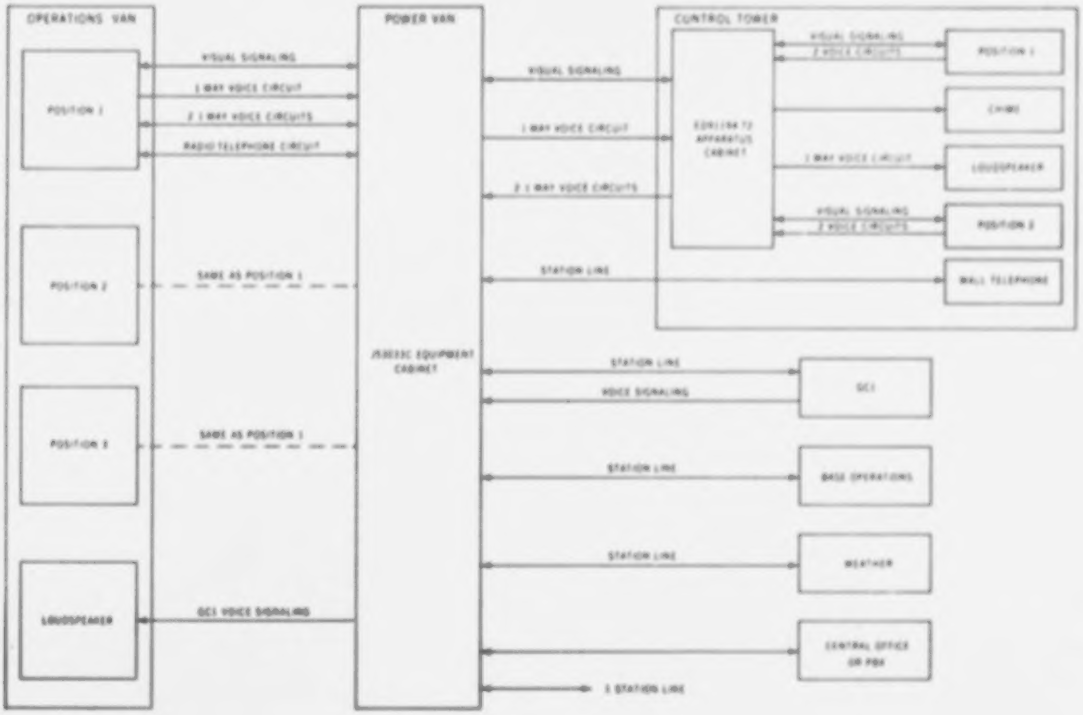
OPERATIONS VAN
POSITION 1
VISUAL SIGNALING
1 WAY VOICE CIRCUIT
2 1 WAY VOICE CIRCUITS
RADIO TELEPHONE CIRCUIT
POSITION 2
SAME AS POSITION 1
POSITION 3
SAME AS POSITION 1
LOUDSPEAKER
GCI VOICE SIGNALING
POWER VAN
EQUIPMENT CABINET
VISUAL SIGNALING
1 WAY VOICE CIRCUIT
2 1 WAY VOICE CIRCUITS
STATION LINE
CONTROL TOWER
APPARATUS CABINET
VISUAL SIGNALING
2 VOICE CIRCUITS
POSITION 1
CHIME
1 WAY VOICE CIRCUIT
LOUDSPEAKER
VISUAL SIGNALING
2 VOICE CIRCUITS
POSITION 2
WALL TELEPHONE
STATION LINE
VOICE SIGNALING
GCI
STATION LINE
BASE OPERATIONS
STATION LINE
WEATHER
CENTRAL OFFICE OR PBX
1 STATION LINE

Figure 5-6. Block diagram of 302 switching unit.

TB3, TB4 and other devices. Duplicate units for other positions are included on the rear of this gate. Additional units are installed there, too. For instance, the J53033S (PBX or central office signaling) unit and a ringing source are placed there. Figure 5-8 illustrates a telephone relay rack of a control tower. Again, the equipment units are identified in the manner already described. For example, equipment J53033F includes relays AC(1), AC(2), AC(3), and AC(4) and associated devices.

Figure 5-6 provides a review of information discussed in objective 662. To illustrate, there are two communications circuits for the GCI station, and visual signaling is only possible at the operations van and the control tower. Likewise, the arrowhead arrangement on the visual signaling lines extending between the operations van, the power van, and the control tower show that the circuits permit two-way operation: Either the tower operator or the controller can originate the signal and light the lamps of the distance station. Furthermore, figure 5-6 shows a one-way voice circuit between the operations van and the control tower, and two one-way voice circuits that begin at the control tower and terminate at the operations van. You must remember that the van personnel press the PTT switch to originate the call to the tower and that the tower operators first operate the PAR or COM switch to prepare their one-way voice circuit, after which they depress the PTT pushbutton, which permits their voice to be received by the van personnel.

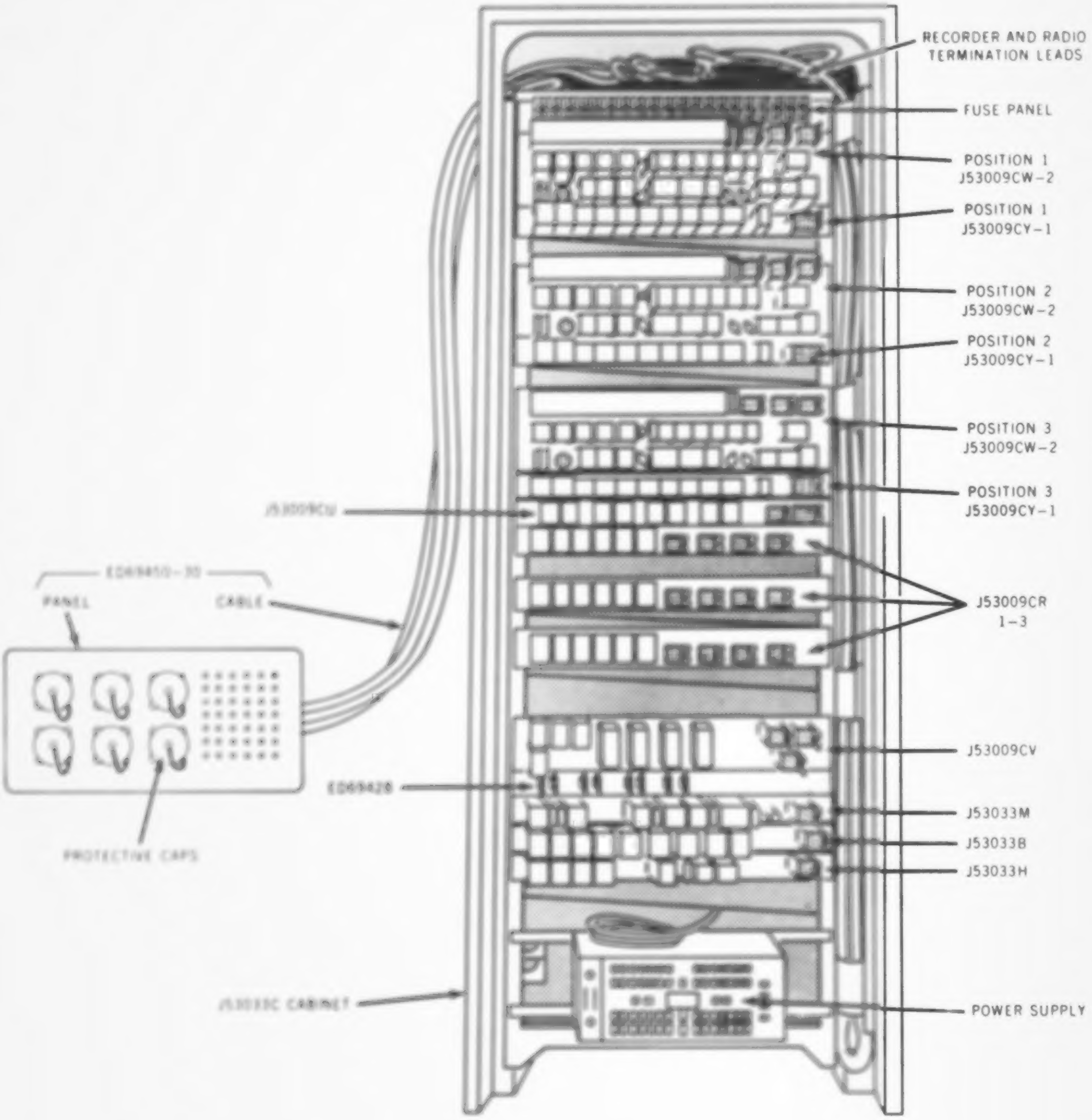
RECORDER AND RADIO TERMINATION LEADS
FUSE PANEL
POSITION 1 J53009CW-2
POSITION 1 J53009CY-1
POSITION 2 J53009CW-2
POSITION 2 J53009CY-1
POSITION 3 J53009CW-2
POSITION 3 J53009CY-1
J53009CU
ED69450-30
PANEL
CABLE
J53009CR 1-3
J53009CV
ED69420
J53033M
J53033B
J53033H
PROTECTIVE CAPS
J53033C CABINET
POWER SUPPLY

Figure 5-7. Power van equipment cabinet, front view.

Exercises (665):

1. Identify the vans that support 302 switching equipment.

2. Name the 302 switching equipment apparatus support unit of the power van.

3. Identify the two 2-way interconnecting circuits for the operations and power vans.

4. Name the two types one-way interconnecting circuits for the operations and power vans.

5. Identify the interconnecting circuit between base operations and the power van.

6. Give the equipment number for the 302 switching equipment power supply at the control tower.

7. Identify the components that are in the top panel on the J53033C equipment cabinet in the power van.

8. For the power van equipment cabinet, give the equipment number for four panels that have relays.

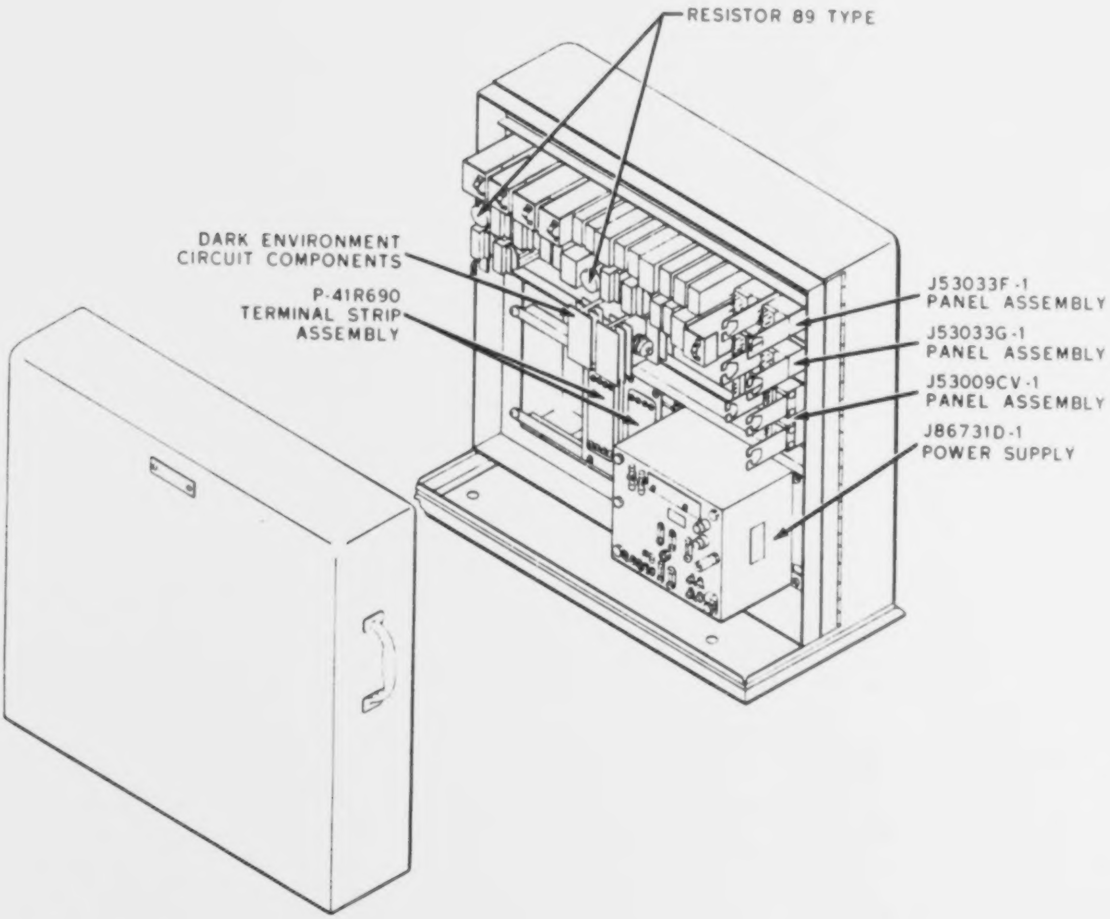
RESISTOR 89 TYPE
DARK ENVIRONMENT CIRCUIT COMPONENTS
P-41R690 TERMINAL STRIP ASSEMBLY
J53033F-1 PANEL ASSEMBLY
J53033G-1 PANEL ASSEMBLY
J53009CV-1 PANEL ASSEMBLY
J86731D-1 POWER SUPPLY

Figure 5-8. Control tower apparatus cabinet.

666. Trace and analyze circuit operations during call progression in the 302 equipment, and name specified components affected or actions that result.

Circuit Operation. Look at foldout 4 and follow the simple straight line drawings of the schematic diagram while studying these paragraphs. We will illustrate and describe a limited number of the circuit operations. This effort should prepare you for your assignment to a work center that has a 302 Switching Unit installed.

We know that there are many features required during a call progression. Consequently, several circuits are necessary to meet the requirements. In addition, various types of calls are provided. For example, telephone calls are made where the central office provides the ringing, and station calls are made that require ringing current from the switching unit power source. Therefore, circuits are provided that produce these variations.

Station line selection. You learned that a depressed PICKUP key for a 1A1 key system operates the A relay in a KTU. The same result is provided with the 302 Switching Unit. However, the controller must do more than press the LINE PICKUP key. Look at foldout 4 as you think about this latter statement. It shows the LINE key at the lower left and the A relay at the upper left. Let us find out how they interconnect. Note the controller's headset, the controller's wire-line transfer key, and the SL relay. Each of these devices affects the A relay circuit. Contact EMB12 of relay SL must operate to complete the operating circuit for relay A. Accordingly, the SL relay must operate before relay A can operate. Yet, to operate relay SL you must connect a ground potential to the terminal identified as K to the left of the relay. The operated LINE key partially does this. The additional unit that connects the ground potential to relay SL is the operated relay WT1. To operate relay WT1, you must place the transfer key in WIRE. (Either selection OFF or RADIO results in opening the circuit for relay WT1.) In addition, the operating circuit of relay WT1 is completed by the installed controller's headset. Thus, we now realize that you must insert the plugs of the headset into the jacks, operate the TRANSFER key to WIRE, and press the LINE PICKUP key when selecting a telephone line. Remember: The PICKUP and TRANSFER keys, as well as the headset, are in the operations van. But, the SL, WT1, and A relays are in the equipment cabinet at the power van.

The operated SL relay provides a holding circuit by operating contact EMB8, completes the operating circuit for the supervisory lamp with contact EMB5, and partially completes the H relay's operating circuit with contact EMB7. At the same time, the operated contacts EMB1 and EMB4 of relay SL connect tip and ring of the telephone station to the line termination equipment of the 302 Switching Unit.

The operated relay A of the station line signaling circuit connects contact 3 with contact 4B to light the LINE or BUSY lamp. Top contacts 2 and 5 open following the operation of relay A to prevent the operation of relay L. Otherwise, relay L would operate with the lifting of the telephone handset from the cradleswitch. In conjunction with the operated A relay, relays PL and C operate. Contact 2 of operated PL completes the operating circuit of relay S. The operated S relay connects 20-cycle ringing current to contacts 4 and 7.

We have said that you selected a station telephone line which requires ringing current from the power van. You must then press the FLASH and RING key. As a result of this key operation, relay FR operates. The operated contacts EMB6 and EMB8 of relay FR extend the 20-cycle ringing current from contacts 4 and 7 of relay S to the line for the telephone station.

The lifted handset at the called telephone provides a complete circuit for conversation between the two people. Foldout 4 shows that contacts EMB1 and EMB4 of relay SL and EMB6 and EMB8 of relay FR are included in this communication circuit between the telephone station and the controller's headset.

Exercises (666):

1. When preparing to call the control tower from the operation van, what actions must you take?

2. Usually, what relays in the power van operate following operation of the line key?

3. What relay in the power van operates following operation of the line transfer key to WIRE at the assistant controller's position?

4. Assuming that the station line to weather station and WIRE keys are operated when you operate the FLASH-RING key, what signals should be noted and where will they be effective?

667. Identify components that operate or actions that result during the HOLD key operation.

Holding a station line. You are aware that all lines in the 302 Switching Unit can be held while you perform another function. Again, this holding condition is accomplished by pressing a HOLD pushbutton.

It is evident in foldout 4 that two H relays operate following operation of the HOLD key. Contact EMB7 of the operated SL relay completes the operating circuit for relay H in the station line signaling circuit. As a result of the H relay operation, relays A, PL, and C return to normal. The released A relay releases contacts 2T and 5T, thereby operating relay L. This operation is the result of the telephone station attendant having lifted the handset. Contact 2 of operated relay L completes the holding circuit for both H relays. We know that this holding circuit is required because the HOLD pushbutton does not lock operated following depression.

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Figure 5-9. Operating circuit for relay A when connected with central office line.

Several methods for releasing the line are possible. You can operate a second LINE key, *the RLS key, the transfer* key to RADIO or OFF, or remove the controller's headset from J53033P- 1.

Analysis of the RLS key connections, shown in foldout 4, reveals that this operated key connects ground to relay CR1. As a result, relay CR1 operates. Operated contact BM12 of relay CR1 completes the operating circuit of relay CR2 and opens the holding circuit for relay SL. The operated CR2 relay opens the operating circuit of relay CR1. The released SL relay opens the operating circuits of relay A, PL, C, H, and the HOLD or SUPV lamp. Release of the RLS key returns relay CR2 to normal. Now the equipment is prepared for another selection.

Exercises (667):

1. List the released relays in the power van following operation of the HOLD key at the controller's position in the operations van.

2. Name five operated relays at the power van following operation of the HOLD key.

3. Tell the devices in the power van that operate to light the HOLD lamp on the operations van consoles.

4. Identify the relays in the power van that operate following operation of the RLS key at the operations van.

668. Identify components, connections, or actions that enable a central office or PBX line selection from the operations van controller's position.

Central office or PBX selection. When considering the selection of a telephone that is connected with a central office, we find that the circuit is slightly different from the station line circuit.

The instructions near the top center and above the PL and C relays on foldout 4 indicate that the A relay of the central office line signaling circuit connects to the J lead. Using this information, try to visualize a relay A and the contact EMB12 of relay SL connected to the J lead. You should realize that the operated SL relay for this selected circuit *completes the relay A operating circuit. However*, in this case, only the relay C operates in conjunction with the A relay. Look now at foldout 5. You will see relay C at the left center of this illustration. Remember: Negative battery is connected to relay A to complete the operating circuit for relay C. Figure 5-9 is a line drawing of this completed circuit. Contacts 3 and A of operated relay C (FO5) connect relay CB to ring side of the line. Note that contacts 1 and 3 of relays and contacts 5T and 6 of relay CT connect relay CB to tip of the line. You learned that resistors in parallel result in less resistance than either resistor has separately. Relay CB has two windings in parallel. This reduced resistance across the central office line operates a relay in the central office; thus, it starts the call progressing through the central office equipment. Return now to foldout 5 and the 302 Switching Unit equipment. At the same time that the central office equipment progresses the call forward, it returns power to the CB relay, thus operating it. Before we consider the effects of the operated CB relay, let us determine further effects of operated relay C.

Contacts 1 and 2T of the operated C relay complete the operating circuit of relay C1. Contacts 3 and 4B of operating relay C1 light the DIAL lamp and shunt the "A" suppression circuit. They also connect ground potential to relays TB1 and TB2 (see FO 5). Contacts 3 and 4T of this same relay connect 24 volts negative battery to relay RS. Relay RS now operates. Contacts 1 and 2B of operated relay RS complete a duplicate circuit to the 3 and A contacts of relay C and therefore insure a connection between relay CB and ring side of the line. Operated contacts 3 and 4B of relay RS complete a connection for the operating circuit of relay CT. Contacts 4 and 5T of operated relay RS short-circuit the receiver of the controller's headset. Figure 5-10 illustrates this circuit to the receiver. Of course, you must recall the activities described in objective 666 to see the sequence in which this circuit is completed. We learned in that earlier description that relay WT1 was operated. Foldout 5 illustrates that the make contacts 3 and 4T of operated relay WT1 complete the operating circuit of relay WT. Contacts 1 and 2B, plus 4 and 5T, of operated relay WT make required connections for this receiver short circuit. Operated contacts 4 and 5B, plus 7 and 8B of this same relay, connect the transmitter of the controller's headset to the primary winding of the "A" induction coil.

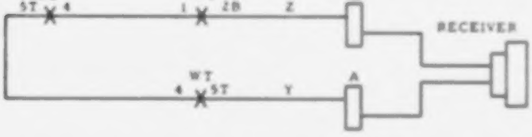


Figure 5-10. Short-circuit of controller's headset receiver.

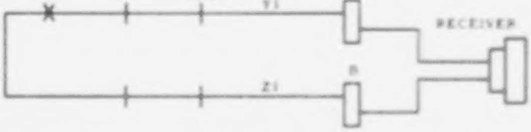


Figure 5-11. Dial shunt for controller's receiver.

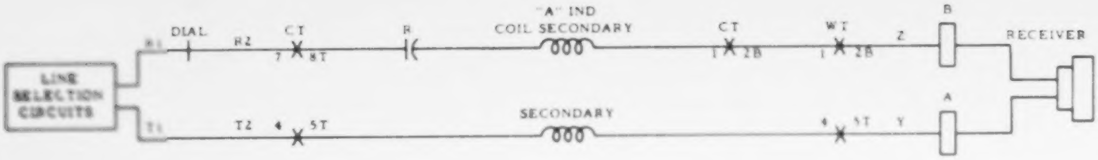


Figure 5–12. Transmission circuit for 302 switching unit.

We learned that relay CB has operated. Contacts 1 and A of operated relay CB are included in the operating circuit for relay CT. Contacts 1 and 2T of operated relay CT provide the relay a holding circuit while, at the same time, contact 1 breaks from contact 3 to open the operating circuit of relay RS. Contacts 7 and 8T of operated relay CT connect the secondary of the "A" induction coil to the ring side of the central office line. Operated contacts 1 and 2B of relay CT connect the receiver of the controller's headset to the secondary of the "A" induction coil. The duplicate circuit connection between relay CB and ring of the line, which was formed by contacts 1 and 2B of relay RS, is now replaced by operated contacts 5 and 6B or relay CT. Contacts 4 and 5T of operated relay CT connect tip of the central office line to the secondary of the "A" induction coil. Furthermore, contact 5T is separated from contact 6 by the operated CT relay to open the low-impedance noninductive winding of relay CB. Since the central office equipment is operating, this increased resistance of the CB relay circuit will not have any major effect on the call's progression.

Having the central office connected with the 302 Switching Unit following your selection of the line, you should hear a dial tone in the controller's headset receiver. Now you can dial the number.

We know that the major results from the operated dial are in the central office equipment. Yet, some changes are made to the 302 Switching Unit circuits. Again, look at foldout 5. At the left of the page you can see the symbol for the dial. The operated dial makes two contacts. One contact directly connects ring of the central office line to tip of the same line. As a result, relay CB momentarily released in this 302 Switching Unit. The second contact short-circuits the controller's receiver for the second time. Figure 5-11 illustrates this new shunt circuit for the receiver. The restored dial reoperates the CB relay and removes the shunt of the controller's receiver.

The lifted handset at the called telephone provides a complete circuit for conversation between the two people. Figure 5-12 shows the circuit between the tip and ring of the line selection circuits and the receiver of the controller's headset. You learned, too, that DC is required for a telephone transmitter when a person speaks into it. Figure 5-13 illustrates the connections for relay TB1, which is the relay that provides DC to the transmitter. In addition, it shows the connections between the controller's headset transmitter and the induction coil primary. Relay TB2 provides DC to plugs C and D, which serve as reserve connections for the controller's headset. Plugs A and B are normally used because their circuit has provision for an emergency battery.

Foldout 5 shows the emergency talking battery supply to the right center of the illustration. It becomes effective when there is power failure; thus all relays are released. Relay AB is one of these relays. It is normally operated; hence it keeps contacts 1B and 2 plus 8T and 9 from shunting capacitors P1 and P12. Following release of relay AB and the shunt of these two capacitors, the DC circuit for the emergency 3 volts of power is complete through the controller's headset transmitter. Figure 5-14 illustrates this circuit.

Exercises (668):

1. List relays that operate in conjunction with the "A" relay when preparing to dial a central office telephone from the controller's position.

2. Which dial contacts shunt the controller's headset transmitter?

3. Identify the operated relays of the power van when the controller is talking with the central office station attendant.

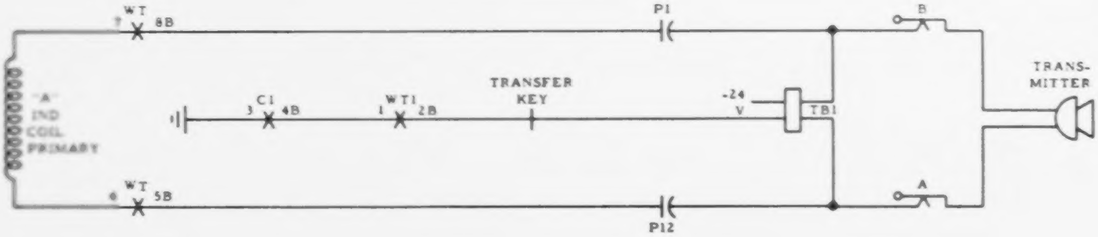


Figure 5–13. DC circuit for operating the controller's transmitter.

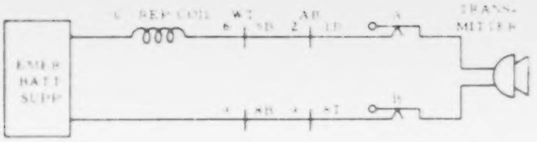


Figure 5-14. Emergency battery circuit.

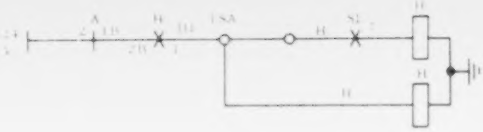


Figure 5-15. Holding circuit for H relay.

4. List the three parallel sets of contacts in the CB operating circuit (see FO 5).

5. Cite the contacts in the AB operating circuit.

669. Note a difference in HOLD key operation results for a station line and central office line selections.

Holding a central office or PBX line. We noted circuit differences when making a station line selection and when making a central office or PBX line selection. For example, the PL relay operated when selecting a station line but did not operate when selecting a PBX or CO line. Accordingly, there will be differences in the effects that result from operating the HOLD key.

When the selected line is served by a central office or PBX, relay PL cannot be released following the operation of both H relays. Secondly, there is no L relay in a PBX or CO signaling circuit. A pair of contacts on the A relay are used to complete the H relay holding circuits following release of relay A. Figure 5-15 is a line drawing of such a holding circuit. Remember: Several lines can be held at the same time and any held line can be reselected by operating the associated LINE key.

Exercise (669):

1. Compare the H relay holding circuit for the station line with that for the PBX line.

670. Identify release actions or results of specified situations when the release key is operated following a central office or PBX line selection.

Central office or PBX release. The equipment release for the CO or PBX line is done in the same manner as described in the last paragraph and in objective 667.

As a result of your depressing the RLS key, relays CR1 and CR2 operate in the way previously described. Also, relays SL, A, C, and H release. Returning to foldout 5, we can analyze the effects after the release of relay C. The released C relay opens the operating circuit of relay C1 and one parallel connection to relay CB. The released C1 relay releases the TB1 and CT relays and extinguishes the DIAL lamp. The released CT relay returns relay CB to normal by opening contacts 5 and 6B (the second parallel connection for operating relay CB). Operation of the transfer key to RADIO or OFF returns the equipment to normal because either position selection opens the operating circuit of relay WT1. Removal of the headset also returns the equipment to normal. The restored WT1 relay releases relays WT and SL. The released SL relay opens the operating circuit of relays A and C. The results that follow the release of these relays have already been described.

Exercises (670):

1. What relay's release is directly controlled by the operated CR1?

2. What relay, when operated, opens the operating circuit for relay C?

3. Tell the relay release sequence following removal of the controller's headset from the jackbox.

671. Use figure 5-16 as needed to determine relays that operate or actions or connections that result when a call is incoming to the controller.

Incoming signal, flashing lamp, and answering. The actions that result when a person selects our 302 Switching Unit for a call are comparable to what you learned with the 1A1 and 1A2 key systems. To illustrate, the incoming call causes a lamp to flash and then, following your operation of the controls to answer the call, the lamps change to steady and the transmission circuit is complete. Of course, you perform more operations with the 302 Switching Unit, and the nomenclature of the devices may deviate from the former systems. We are not going into the operational procedures that produce the circuit effects because you should be able to determine them now. In an effort to help you recognize the circuit devices and their effects, we will list more of them.

The lifted handset at the telephone station operates relay L in the station line signaling circuit. The operated L relay, in turn, starts a relay operational sequence which flashes the lamp. This sequence is similar to the method used in the 1A1 key system where the FA, FB, WS, WT, and W relays provided winking lamps. In this system, relays FL, ST, A, B, and FL1 provide the interruptions in the lamp circuit. However, the interruptions are of longer duration than was the wink so that the lamp provides a flashing effect. Figure 5-16 includes these flashing circuit relays.

NOTE: We are not showing the foldout that has relays L and FL and the connections between relay L and relay FL of the J53033N unit or the FL connections between the J53033N unit and the J53033M unit (fig. 5-16) because we must limit the number of complex circuits and diagrams that we use in this text. We ask you to take for granted that the ground at contact 12 of relay FL1 (fig. 5-16) completes the operating circuit for a relay FL. Furthermore, remember that contacts of the operated L and FL relays complete the operatin circuit for the LINE lamp. The operated FL relay, in turn, connects ground to relay ST (also shown in fig. 5-16).

Operated contacts 5 and 6T of relay ST complete the operating circuit for relay A. Then the operated relay A completes the operating circuit of relay B. The operated B relay opens the operating circuit of relay A. Now the operating circuit relay FL1 is complete. Included in this operating circuit are contacts 3 and 4T of relay B and 2 and 1T of relay A. The operated relay FL1 disconnects ground from leads FL. Consequently, relay FL is released. The released FL relay opens the LINE lamp circuit. Your analysis of figure 5-16 should also disclose that the released relay A opens the operating circuit of relay B. The released B relay returns relay FL1 to normal while completing the operating circuit of relay A again. Here again, the circuit is prepared for the relay operational sequence which provides an interruption in the lamp signaling circuit.

Since you would normally have the headset inserted in the associated A and B jacks, you then respond to the flashing lamp by making sure that the transfer key is in WIRE and operating the LINE key. As a result, relay SL operates to complete the operating circuit of relay A (FO 4), to complete the circuit for the SUPV lamp, and to connect the originating station with the transmitting circuit of the controllers. The operated relay A makes the contacts that light the LINE lamp at the three operations van positions steadily. The same contacts that provide the steady power to the lamps open the flashing lamp circuit. You should also recall that the operated A relay opens a set of contacts that prohibit the L relay from operating.

The incoming voice signal from the GCI station is different in that the 106B loudspeaker for the operations van is used. The voice signal line from this station is connected to contacts of the A relay. The incoming voice is heard by the people of the operations van; then one of them operates the LINE key. Consequently, the A relay is operated. This operated relay opens the loudspeaker circuit while connecting the talking circuit of the controller with the GCI station telephone line.

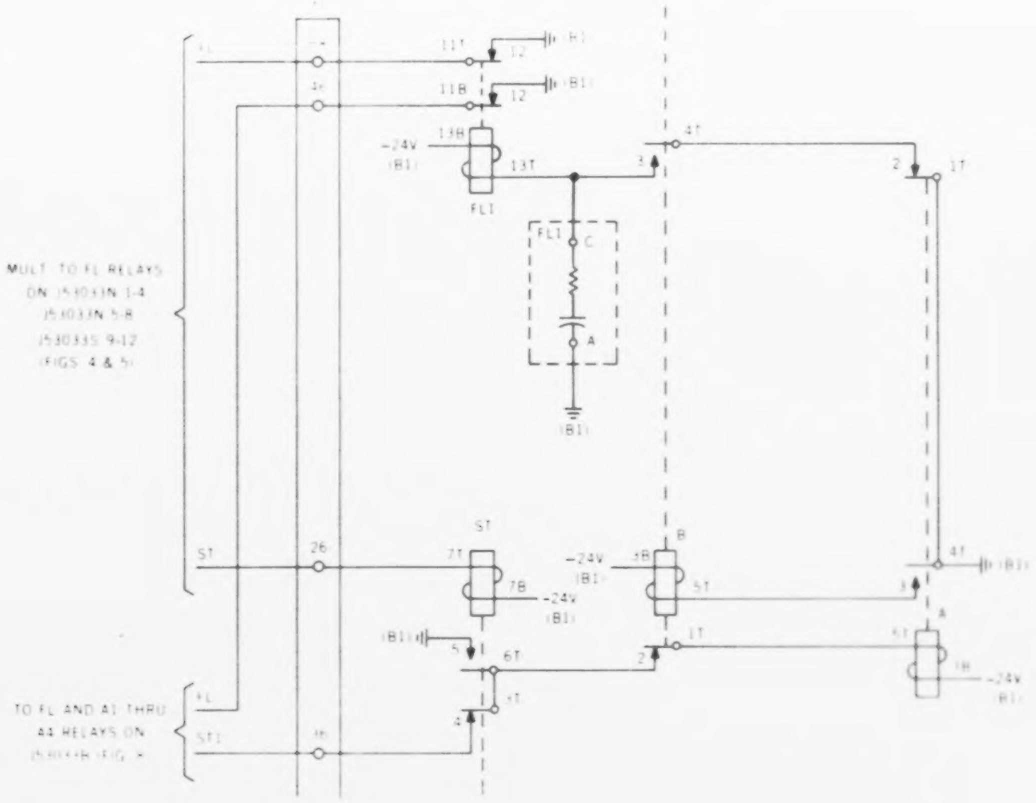


Figure 5–16. Flashing lamp and audible signal control circuit.

Exercises (671):

1. What potential is required to begin the flashing lamp sequence for the controller's position?

2. Tell the connection that provides the potential of exercise 1.

3. Give the operational sequence of relays A and B in the J53033M unit.

672. Identify the request and acknowledgement equipment by citing operations and conditions that result in specified circuit actions.

White lamp signal at requesting location. We learned when describing the request and acknowledgment signaling circuits that you turn the ON switch and depress the WHITE pushbutton when making a request. Foldout 6 will permit us to analyze the effects of these two control operations.

Before we consider the circuits, however, let us note some of the features of this schematic. At the left side of the illustration you can see a block labeled OPERATIONS VAN. Within this block is a smaller block. The latter block represents the J53055A key and lamp unit, which is installed in the operations van. The key and lamp unit is shown to have eight lamps and eight keys. Positioned near the key symbol are contacts that complete or break circuits following operation of the key. For example, by pressing the RED key you connect ground at contact 6 to the A4 lead. The A4 lead is also connected to the connector pin 26 of the cable for the operations van. This cable is multipled with position 2 so that the lamps at each position will operate when the key is operated at any position. Lead A4 is further connected to lead A4 in the power van. In this power van the A4 lead is also multipled to position 3. This cable that extends between the two vans is shown terminated with the J53033C equipment cabinet in the power van. Included as units of the equipment cabinet are the J53033H, J53033B, and J53033F equipment. The A4 lead is connected with terminal 36 of the terminal strip for J53033B. Tracing this A4 lead further results in observing its connection with CR1 and relay A4.

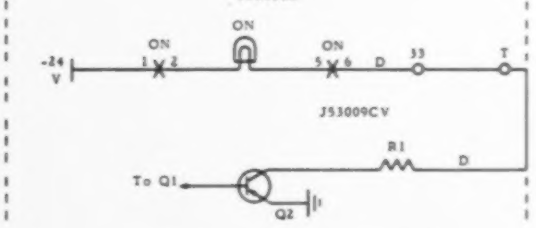


Figure 5-17. ON lamp operating circuit.

Now, let us consider the operation of the ON key. First, the operated ON key results in lighting the ON lamp. The 24-volt battery potential for this lamp is connected to contact 1 of the ON switch. The ground potential for this lamp is found in the dark environment lamp control circuit. Foldout 7 is a schematic diagram of this latter control circuit. Figure 5-17 illustrates the operating circuit of the ON lamp. Remember: The operations van personnel normally work with the overhead lights either dim or off so that they can read the radarscopes more efficiently. So, the LP CONT switch is regularly positioned at ON. This switch is at the upper right in foldout 7. When this switch is ON, the CO relay is released. In addition, the R4 variable resistor permits you to adjust the intensity of the lamp. You make this change in the lamp brilliance by changing the voltage at the D leads. These leads are shown at the lower left in foldout 7. You should realize from your tracing of foldout 7 that there is a completed DC circuit at all times for the Q2 transistor. The negative voltage for this circuit is at contact BM8 of relay CO. From this contact you trace to terminal 21 of terminal strip B, through resistor R6, resistor R4, resistor R1, and then to ground through the Q2 transistor. Of course, transistor Q1 and resistors R2 and R3 form a parallel branch to R6, R4, and R1. Together the two branches permit you to determine the current in the position lamps. For example, the movement of the slider on R4 changes the voltage at the base of transistor Q1. As a result, the current in Q1 is changed. All current changes in Q1 are likewise observed in transistor Q2. Since Q2 is in series with R1, R4, and R6 and they form the D lead regulator circuit, this current change causes a different voltage to be reflected at the D leads. Ground potential is at the D leads when the LP CONT switch is turned to OFF.

Depression of the WHITE pushbutton likewise lights the WHITE lamps for the three positions in the operations van. Figure 5-18 illustrates the operating circuit for one position lamp. Since contacts 5 and 6 of the ON switch are included in this lamp circuit, it is evident that the circuit would not be complete without your having operated the ON switch first. Also, since transistor Q2 is included in this lamp circuit, it is obvious that the adjustment of variable resistor R4 controls the brightness of this lamp. (NOTE: The D lead of foldout 6 is not shown with multiple connections to the associated positions. Hence, one dark environment lamp control circuit is used for each position.)

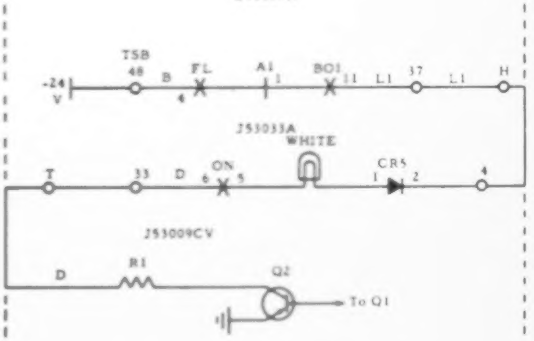


Figure 5-18. WHITE lamp operating circuit.

You should remember that the WHITE lamp must flash when you press the button for request. The operational sequence that flashes the lamp includes the FL relay, which is operated when the power is turned on for the equipment. This FL relay is near the middle of the page in foldout 6. Operated contacts 5 and 6 of the WHITE switch start this flashing because they connect ground to relay K1 in the J53033B unit. Figure 5-19 shows the operating circuit of relay K1. Contact M1 of operated relay K1 completes the operating circuit of relay BO1. Relay BO1 remains operated following your release of the WHITE pushbutton because of its holding circuit through contact EMB8. This operated contact 8 also completes the operating circuit for relay BR1. The operated BO1 relay connects ground at contact EBM12 to the ST1 lead, which in turn is connected to relay A in the flashing and audible signal control unit (fig. 5-16). Figure 5-20 illustrates this operating circuit for relay A. We learned that the A relay works in conjunction with the B relay and the FL1 relay. The operation and release of relay FL1, in turn, releases and reconnects contacts 11B and 12. These contacts then release and reoperate the FL relay (see FO 6). While the FL relay is released, the operating circuit to the WHITE lamps is open. Then the reoperated FL relay completes the operating circuit of the lamps again. The multiple connections for the cables provide the lamp circuits to positions 2 and 3.

Flashing lamp is also required at the control tower. The connection that provides this response is shown at the center of the page and near the bottom of foldout 6. By tracing the L1 lead from this point you will find that the intermittent operation of relay FL also places 24 volts negative battery at interrupted intervals to an AC relay circuit of the control tower. Accordingly, the release and operating sequence of the FL relay releases and reoperates the associate control tower AC relay. The affected AC relay opens and makes contacts that flash the WHITE lamps at the tower positions. The tower equipment is not shown in foldout 6; therefore you cannot trace all the connections while using the illustrations of this course. We repeat, we have included a minimum of illustrations, so you must use technical order foldouts to trace all of the complete circuits.

The tower operator operates the WHITE pushbutton to acknowledge the request signal. This action stops the flashing of the WHITE lamp. The operated WHITE button in the tower connects ground potential to lead B1, (see the bottom left center of foldout 6). Thus, relay AC(1) operates. Contacts 2 and 5 of operated relay AC(1) complete the operating circuit for relay A1. Operated contacts EBM3 of relay A1 complete a holding circuit while, at the same time, removing the ground potential to lead ST1. Accordingly, this removal of ground potential from the flashing signal control circuit prevents the sequence relays from flashing the lamp. Contact EBM2 of operated relay A1 connects uninterrupted 24 volts negative battery to the tower lamps. Contact EBM1 of this relay provides the steady negative battery to the WHITE lamps at the operating van.

The flashing and steady lamp operating principles for the AMBER and GREEN lamps are the same as for the WHITE. The difference in tracing their circuits is that you use lead L2 and relays K2, BO2, BR2, and A2 for the AMBER lamp and lead L3, relays K3, BO3, BR3, and A3 for the GREEN lamp.

Exercises (672):

1. What condition enables the AMBER lamps at each console to illuminate simultaneously when the associate key is operated at only one position?

2. What device is to be considered and what should be its condition if you find the CO relay of the J53009CV assembly in the power van operated while inspecting the J53033C equipment cabinet?

3. Identify the operated relays in the J53033B unit that enable the WHITE lamps to flash.

4. In the power van J53033B unit, identify the operated relays and their contacts that enable the WHITE lamp to flash at the control tower.

5. State the procedure that stops the flashing GREEN lamp at the tower and indicate the potential it provides to the activating device of the J53033B unit in the power van.

6. Identify the operated relays and their contacts in the J53033B unit of the power van that enable the steady AMBER lamp at the operations van.

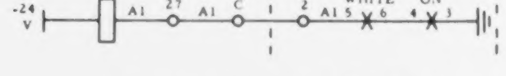


Figure 5–19. Operating circuit for relay K1.

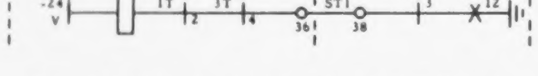


Figure 5–20. Operating circuit for relay A in J53033M unit.

673. Given specified lamp or control conditions, determine activating situations or subsequent actions.

Emergency Condition. Relays K4, BO4, BR4, and A4 are used with the Red lamp, and they function in almost the same manner as do the preceding relays. However, we know that there must be a difference, because the RED lamp flashes only when the tower operator presses the RED pushbutton at his or her position. Then the lamp becomes steady following the operation of the RED button at the controller's position. This equipment functions in the desired manner because the operated AC(4) relay completes the operating circuit for relay K4. Operated contacts 5 and 2 of relay AC(4) connect ground to lead B4, thereby operating relay K4. Operated relay K4 does the same functions as previously described; for instance, it completes the operating circuit for relay B04, connects ground to lead ST1 of the flashing signal control circuit, and connects interrupted negative battery to the RED lamps. When the controller presses the RED pushbutton, ground potential is connected to the A4 lead. This grounded lead operates the A4 relay. The operated A4 relay removes ground from the ST1 lead while connecting uninterrupted negative battery to the RED lamps of the operations van and control tower.

NOTE: If the controller makes a request by pressing the RED button, the described conditions prevent the RED lamp from flashing. To illustrate, the grounded A4 lead operates the A4 relay, which in turn completes the operating circuit of relay K4 with operated contact EM9. Secondly, the ground connection, which starts the flashing signal control relays operating in sequence, is opened at contact EBM12 of relay A4. At the same time, negative 24 volts battery is connected to the RED lamps.

The operation of subsequent colored pushbuttons extinguishes the lamp that preceded it. For example, the operation of the AMBER button restores relay A1. Foldout 6 shows the connection that releases these relays. Contact B9 of released relay BO2 provides the −24 volts for relay BO1. Yet the operation of the AMBER button completes the operating circuit of relay K2. The operated relay K2 then operates relay BO2. Now relay BO1 must restore. Research of the connections for each of the BO relays will reveal that the operated RED button shuts off the GREEN lamp. Also, the operated GREEN button shuts off the AMBER lamp. Further analysis reveals, however, that the operated BO relay for the fourth circuit (BO4) does not prevent you from signaling that another airplane is approaching. You can press the WHITE and AMBER pushbuttons to identify the plane positions while the RED lamp circuit is operating.

NOTE: With the AMBER lamp and circuit operated, following depression of the AMBER pushbutton to extinguish the WHITE lamp, you can press the WHITE button again. As a result, the WHITE and AMBER lamps will glow simultaneously. The −24-volt battery potential at contact M1 of relay BR2 makes this feature possible.

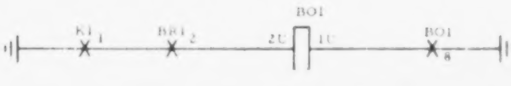


Figure 5–21. Shunting circuit for relay B01.

A lamp can be extinguished by the request originator through his or her operation of the associated key for a second time. To illustrate, assume that the WHITE lamp is operating without interruption. This condition prevails because relays BO1, BR1, and A1 are operated. Now your depression of the WHITE button for the second time reoperates the K1 relay. As a result the ground potential on contact M1 at relay K1 is extended to contact EBM2 of operated relay BR1. Since this EBM2 contact is now connected with the 2U terminal at the winding of relay BO1, the relay is shunted. Figure 5-21 illustrates the shunt circuit. The A1 relay is restored because of the release of relay BO1. Having restored relays BO1 and A1, you release the WHITE switch. This action restores the K1 relay. The ground at contact M1 is thus removed from the operating circuit of relay BR1. The three relays (A1, BO1, and BR1) are now normal again.

Exercises (673):

1. Tell the potential and the action that provides it which flashes the RED lamp at the operations van positions.

2. Assuming that the GREEN lamp is lighted steadily, identify the circuit conditions that enabled it and the associated actions that affect the AMBER lamp.

3. Give the release action for the GREEN lamp that shunts the holding relay and list the devices that form the shunt.

674. Analyze selected 302 schematics to identify devices, connections, or actions when given a specified situation.

One-way voice selection. Foldout 7 also shows the voice circuit components included in the power van. We have seen that the components in this van are under the control of the controllers and assistant controllers.

We will consider the operations van-to-control tower talking circuit, which is originated by a controller. We are also assuming that you are at the first controller position when originating the radio call. Your operation of the PTT pushbutton starts the procedure. You can see that contacts 2 and 1 of the PTT button complete the operating circuit of relay PT1. Figure 5-22 shows this relay operating circuit. Operated contact 8 of relay PT1 completes the PTT lamp operating circuit.

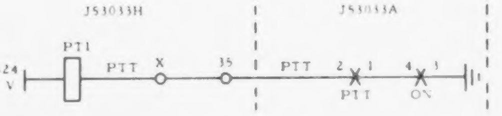


Figure 5–22. Operating circuit for relay PT1.

NOTE: There are three PT1 relays, one relay for each of the three positions. Yet, the PTT lamp at all positions operates regardless of the relay that is operating. This feature results from the connection provided by contact 8 at each PT1 relay.

Contacts 4 and 6 of operated relay PT1 complete the connections between the controller's radio and wire termination (see FO 5) and the primary of the "A" induction coil. The voice circuits are shown with heavy black lines. Accordingly, the primary of the induction coil is connected by means of leads 13 and 14 to the controller's headset, and the secondary of the induction coil is connected with tip (T) and ring (R) at the tower. Figure 5-23 shows that the T and R leads terminate at the loudspeaker in the control tower.

The operated PTT pushbutton also completes the operating circuit for relay CH in the control tower. The method used for operating this relay is different from any of the previously described circuits. In this case a simplex circuit is used. Figure 5-24 should enable you to analyze the CH relay operating circuit. You can see that the operation van controls connect −24-volt battery potential to the C lead. This C lead is terminated at the center point of two coils. From this midpoint the circuit splits so that the circuit current has two paths to the tower. You know that two paths (branches) are indicative of a parallel circuit. Furthermore, the total resistance of a circuit containing parallel branches is less than the resistance of either of the branches. Reduced resistance results in greater current in the circuit and permits greater distance between the van and tower. The two branches are formed into one path again before entering the CH relay. This one lead is also referred to as the C lead.

The one conductor leading from the opposite side of the CH relay is referred to as G1. The G1 lead is also installed so that it forms a parallel circuit between the tower and the power van. Then, from the power van to the grounded terminal it likewise is a single lead. We learned that one reason for this installation arrangement was to increase circuit current. A second reason for this connecting method is that there was no need for including an additional pair (labeled C and G1) in the cable between the tower and power van. The transmitting pairs (T and R plus T1 and R1) serve as the conducting circuit. This installation method of using a simplex circuit and the transmitting pairs in the cable is valid for a third reason. The simplex coils offer large opposition to the talking current. Thus they restrict this AC from bypassing around the tower and van receivers. You should recall the principles of magnetism and how magnetism provides high impedance to AC.

Figure 5-24 also indicates that the CH relay operates following your operation of all colored pushbuttons. The same simplex circuit is used to operate the relay following depression of those control buttons. A simplex circuit is also used for operating the AC relays in the tower. Of course, in the latter relay circuits L1 is the −24-volt source termination

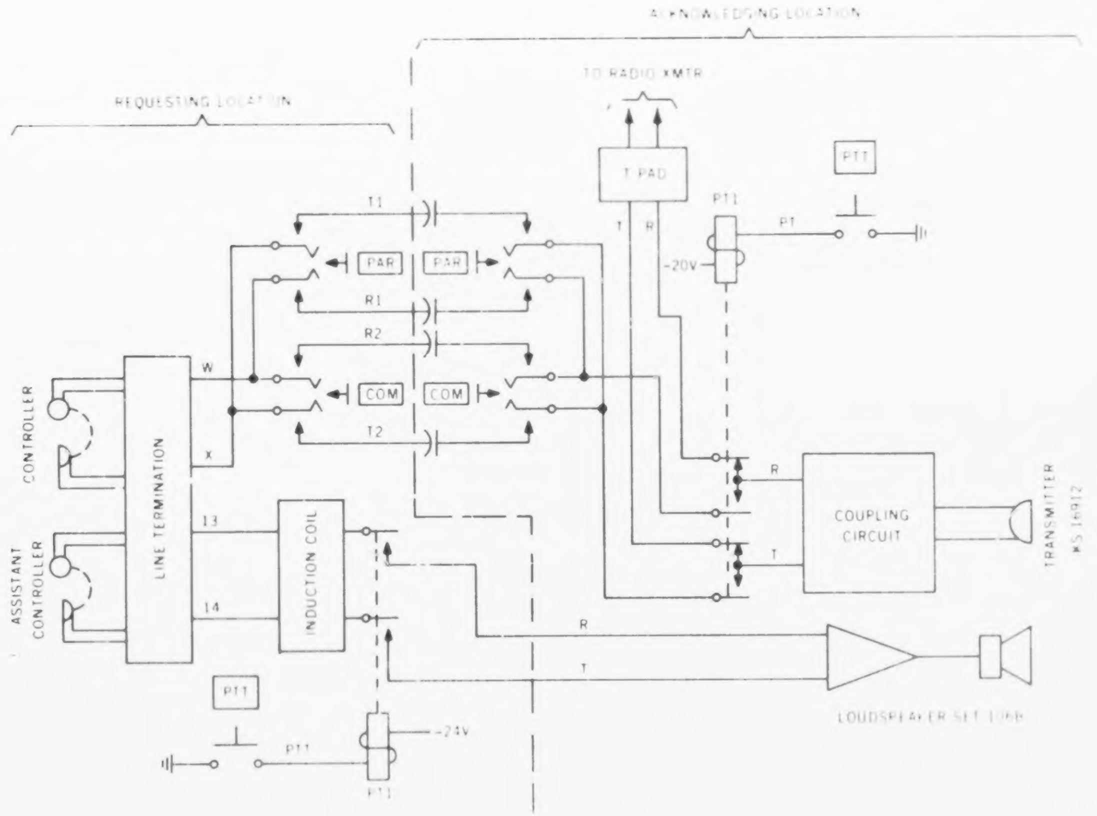


Figure 5-23. Schematic diagram of one-way voice circuits in 302 switching unit.

lead and lead LG connects to the grounded terminal. Similarly, rather than using the T1 and R1 cable pair, this circuit uses the R2 and T2 cable pair.

We learned that the controller operates the PAR switch at his or her position to complete the one-way precision approach radar voice circuit. Foldout 6 shows that this operated PAR switch connects the X and W leads from the controller's headset to the T1 and R1 leads of the cable. Figure 5-23 also reveals this switch connection. The COM switch operating principle compares to the PAR switch operation. From the simplified schematic of figure 5-23 you can realize that the circuit difference is that the cable conductors T2 and R2 are connected by the operated COM switch to the X and W leads from the controller's headset.

Exercises (674):

1. What is the result when you operate the PTT switch at the controller's console?

2. Identify a tower relay that operates following operation of the ON and WHITE keys at the operations van.

3. Assuming that the CH relay in the tower equipment has failed, identify the power van terminal strip terminal to inspect for ground.

4. Name the connecting terminals for the COM circuit at the J53033F unit.

675. Cite the effects of a radio selection.

Radio selection. Normally, the controller is responsible for the radio communications. He or she places the transfer key in RADIO to complete the equipment connections.

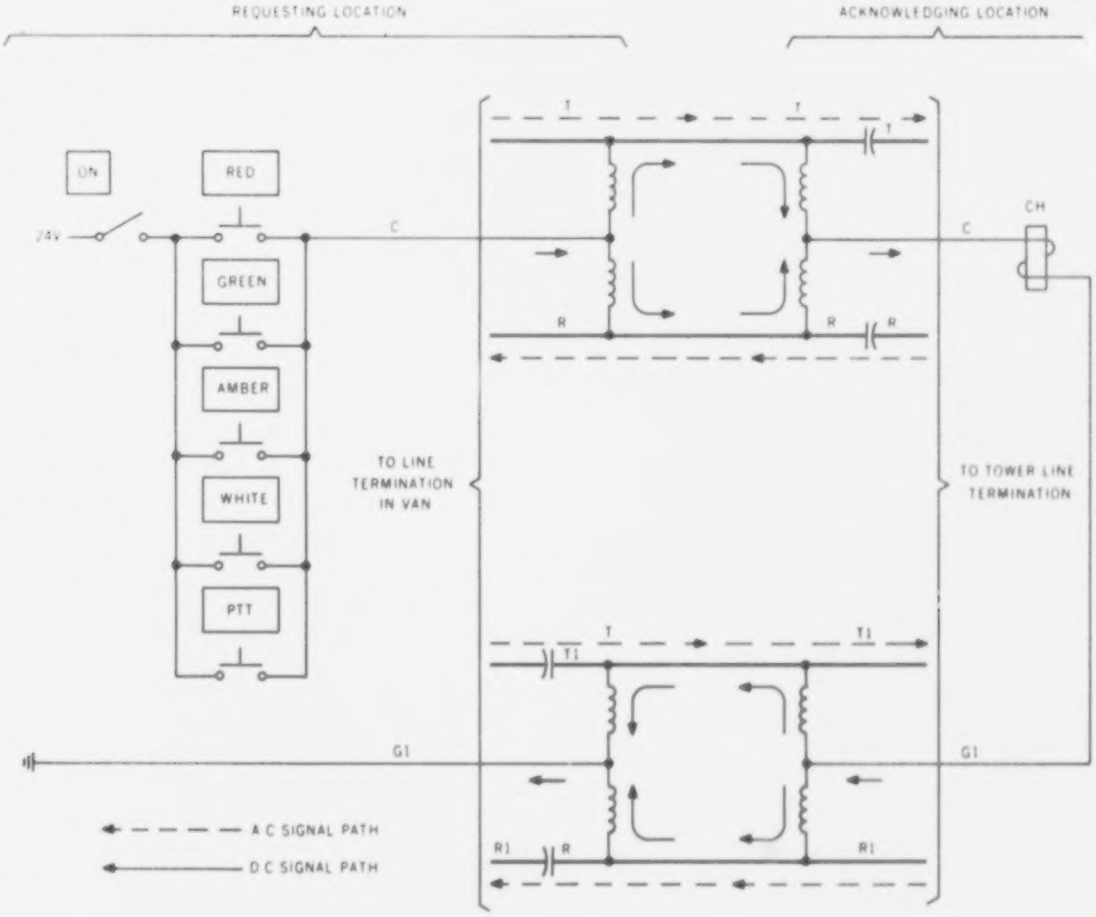

REQUESTING LOCATION
ACKNOWLEDGING LOCATION
ON
RED
GREEN
AMBER
WHITE
PTT
24V
C
T
R
C
CH
TO LINE TERMINATION IN VAN
TO TOWER LINE TERMINATION
T
T1
G1
R1
R
A C SIGNAL PATH
D C SIGNAL PATH

Figure 5-24. Simplex circuit.

The effects of this switch operation can be determined by looking again at foldout 5. The radio selection removes the ground potential to relay WT1, which, in turn, opens the operating circuit of relay WT. Hence, both relays return to the unoperated condition. Contact 3B of relay WT1 places ground to relay TB1 so that talking battery is available to the controller's headset. Contacts 2B and 3 and 5T and 6 of released relay WT connect the controller's receiver with windings of the D repeating coil. Additional windings of this repeating coil are connecte to the T and R conductors of the radio equipment at the control tower. Contacts 8B and 9 and 5B and 6 of released relay WT connect the controller's transmitter to a winding of the C repeating coil. The remainder of the repeating coil windings are connected to a 1C pad. This 1C pad and the impedance-matching resistors A, B, and A1 permit adjustments to be made which improve the radio reception and transmission. Contacts 10 and 11T of release relay WT open the operating circuit to a speaker-transfer relay in the radio receiver.

Your analysis of the controller's radio termination should also show that the connections between the headset and the radio equipment remain when the transfer key is placed in the OFF position. However, in this latter circumstance the TB2 and TB1 relays do not have a connection to ground. Therefore, the transmitter for the controller is unable to function because it has no DC current.

When you research the technical order that applies to your 302 Switching Unit, you will find many additional schematics and wiring diagrams. They include circuits that function in the same manner as the ones which we have described. For example, you will find relays designated as TB3 and TB4. Each of them serves the assistant controller's headsets. Yet they operate like relays TB1 and TB2, which are shown on foldout 5. Likewise, you will see several additional SL relays. We described the principle for their operation when covering the SL relay of foldout 4. Furthermore you will find a circuit having an R relay. We did not illustrate it because it operates in the same manner as the R relay of the 1A1 key system; hence, the incoming AC signal from the central office operates it. The operated R relay then starts the LINE lamp flashing. You should now be familiar with flashing lamp circuits, also. The 302 Switching Unit circuits that remain should then become known during your study while on OJT at the organization that is responsible for the equipment.

Exercises (675):

1. Name the two contacts that connect ground to relay TB2.

2. Identify the contacts that remove the ground from relay TB1 when the transfer key is operated to OFF.

5-3. System Maintenance

To keep communications equipment operating continuously, you must perform high-quality maintenance. Quality work is the result of personal discipline—the specialist who has a careless attitude is quite likely to be a trouble making rather than a trouble removing person. Equipment should be inspected, corrected, and returned to service as soon as possible. Inspections, testing, and adjustments are best accomplished when programmed. The maintenance schedule should provide for visual and operational inspection within a specific period of time. You are not expected to see each connection each time. Yet, each should be observed at least once during this scheduled period. This procedure will disclose minor faults that could result in future major faults.

We are separating system maintenance into four categories: inspections, performance tests, trouble location, and trouble repair.

676. Specify typical 302 system areas to inspect and representative things to look for.

Inspections. It is important that you consider safety while inspecting the 302 Switching Unit. To illustrate, use care when inspecting connections, because movement of conductors and cables can break connections and can short-circuit terminals. In addition, careless removal of the unit cover may break elements or bend contacts.

We are listing things to look for when visually inspecting the equipment in the three areas we have mentioned in the above text. However, there may be other features that you will consider or that your supervisor will require.

Operations van. At each position, check the switches for looseness or sticking. In the same manner, determine if the dial and potentiometer have a smooth and positive response. Look at the plugs and jacks for the headset to determine if they are bent or are corroded. Examine the headset cords for worn or exposed areas. Inspect the lamps and lamp jewels for cleanliness. A blackened lamp should be replaced; it may function temporarily, but its life is limited. Observe exposed cable conductors for signs of stress or deterioration.

Power van. Open the equipment cabinet door and look in the fuse holders to determine if there are any spare fuses missing or blown fuses. Inspect for loose screws, broken conductors, missing dust covers, and overheated devices. If a dust cover for a relay is missing, look for crossed contact wires or bent springs. Secondly, determine if the wire wraps at the relay terminals have become loose or if there is dirt on the contacts or terminals. Swing out the equipment racks and take notice of the condition of the wheel and bearings. They should allow the racks to swing out freely from the cabinet. Separate the racks and look for loose or broken connections, loose screws, signs of arcing at relay contacts, missing relay covers, and overheated devices. Check for clean and tight battery connections. Inspect the recorder patch cords for signs of excessive wear. Look for cables that may be out of place.

Control tower. At each position, check the switches for free movement. Inspect the condition of the lamps and lamp jewels. During rotation of the volume control, see if it is binding. Note also if it is firmly attached to the shaft. At the telephone relay rack, look for loose screws. Then remove the equipment cover and observe the fuse holders for missing spare fuses or blown fuses. Inspect for missing relay covers, burnt devices, arcing between terminals and contacts, and broken connections.

Exercises (676):

1. Name the two facilities which require an inspection for lamp quality.
2. At the two facilities listed for exercise 1, which devices will you inspect for free movement?
3. What facility requires an inspection for signs of damage to relays and the condition of the battery?
4. What two facilities have fuses for inspection?
5. Give the plug and cord faults to inspect for.

677. Tell when a performance workcard is to be used and what information is included on it.

Performance Tests. We know that the individual components are not normally isolated to be tested. They are determined to be functioning by operating the equipment. For example, you learn if the SL relay in the J53009CR unit, the A relay in the J53033S unit, and the C, PL, and S relays in the J53009CW unit are operating properly by selecting a telephone station for the system and by pressing the LINE key. Of course, operation of the HOLD key insures that the H relays function, and talking to the person at the station reveals that relay TB1 is good. In this manner all components are tested.

There is no need for us to describe all the performance tests that you make for your type of 302 Switching Unit, because there is a preventive maintenance workcard set available that gives this information. You will find that these workcards are colored. The green cards include information about performance routines that are done while the equipment is operating. The pink cards describe service routines that are done while the equipment is operating. The pink cards describe service routines which consist of work procedures that do not usually require the equipment to be operating.

Let us think of what information you should expect these maintenance cards to have. First, they will identify the test. To illustrate: one test determines the condition of the station line between the operations van and control tower. Second, you will be informed of the time that it should take to complete the test. Furthermore, you will be told what controls to operate and what indications should be noticeable if the equipment is operating correctly. For instance, for the station line test you know that you will place the headset plugs into the A and B jacks, put the transfer switch at WIRE, and depress the LINE key for the tower circuit. Consequently, LINE or SUPV lamps should illuminate at all operations van positions. Then you must operate the FLASH & RING key. As a result of these actions, you should be able to talk with the tower operator using the tower telephone. Additional test procedures will follow; for example, a return call and the symptoms that accompany it. If you need additional testmen and materials to complete the test, this information is also included. Finally, you are told to record the results of the test and to notify the supervisor of any abnormalities.

NOTE: Notify your supervisor, also, of any discrepancies that you may find in the workcard instructions. These instructions must conform with the maintenance instructions of the current technical orders.

The loudspeaker 106B performance is an additional test which we will mention. For this test you ask an associate at the GCI station to speak while using the voice signaling circuit. You then listen for a moderate signal. The adjustment for this signal includes the 1C Pad, 89 type resistors, shown in foldout 5. The control that determines their resistance in the circuit is installed in the center of a terminal strip. This control and the loudspeaker volume control are operated together until you reduce any telephone transmitter howl and yet reach the desired listening level.

Since these performance tests involve personnel at locations where these people may have little time to help you, plan your test carefully. Take advantage of the time when the equipment is not required because of reduced air operations. If you cannot complete all checks at this time, go on to others that you can do, but don't omit any procedure. At a later date perform the one omitted, and do it at a time that is as close to the scheduled time as possible.

Exercises (677):

1. What is the usual method for determining that a specific equipment unit is faulty?
2. What type routine is indicated on a green workcard?
3. Tell three types of information on the workcard of exercise 2.
4. When will you use a pink workcard?
5. Give two types of information on the workcard of exercise 4.

678. Given typical equipment trouble symptoms, identify applicable additional symptoms, probable trouble fault, or example procedures to use in attempting to isolate the fault.

Trouble Location. Trouble location in a 302 Switching Unit includes the isolation of the fault to the operations van, to the power van, or to the control tower. We know that each specialist should develop methodical procedures for determining troubles. For this reason, we will not list all troubleshooting steps. Similarly, we will not list all the troubles which may occur in a system, because there are many possibilities for each system and there are several systems. Thus, we are disclosing only example trouble procedures.

Assume that controller number 3 has reported a failure of the fifth LINE PICKUP key to function. Verify the report by pressing the key again. Take note of the lamps at this position and on the other operations van positions. If the lamps fail to operate at this position but light at the other positions, then the trouble is isolated to this position. Although it is not probable that both the LINE or SUPV lamps would become open at the same time, you could check each of them. We would assume that the fault may be a connection common to both. Look at your technical order diagrams to see what connection could be common. The station line visual and voice signaling schematic shows a strap between each line lamp; thus, each lamp is grounded by means of a common connection. A visual inspection of this strap should reveal the condition of the connection. However, there are instances where a connection looks acceptable but a resistance check shows it to be a high-resistance connection. The line selectio functional schematic shows the same type common ground connection for the SUPV lamps at each operations van position. Further analysis determines that the ground connection in the dark environment lamp control unit (J53009CV) at the power van could not be at fault because it serves the lamps at all positions. The most rapid solution to the problem may be to replace the 623A key unit and lamp socket assembly 61A. If these replacement units correct the failure, you will then tag the faulty units and send them to depot maintenance for repair.

Note, though, that the preliminary report listed "failure to function." You must determine if there was another trouble symptom, in addition to the lamp failure. In other words, the operated LINE key also must complete the talking circuit between the telephone station and the controller's termination circuit. The schematic of foldout 4 shows that the operation of the SL relay in the power van results in making the contacts that complete this talking circuit, as well as completing the SUPV lamp circuit and the A relay circuit. To see if the SL relays are operating, look at the J53009CR unit.

A second trouble analysis can be made following the report that the operation of the WHITE pushbutton at the number 1 controller's position results in a steady signal. Now you verify this report and, in addition, press the WHITE pushbutton at the two remaining controller positions. Assume that a steady lamp resulted from their operation, too. These symptoms reveal that the trouble is common to the three positions; probably it is a power van unit trouble. Search of foldout 6 shows that the same ST1 lead starts the flashing circuit operating for all the request and acknowledgment lamps. Hence, you should press one or all of the remaining colored switches. If flashing does not occur, you should consider the power and flashing unit to be at fault or the ST1 lead is open. Conversely, if the operated colored lamps (amber and green) result in a flashing lamp, then our trouble is probably defective contacts on relays K1, BO1, or A1. Replacement of the J53033B unit should reveal if this request and acknowledgement unit is at fault; yet, you must attempt to correct the defective contacts before replacing the wired-in assembly.

Exercises (678):

1. Assuming that the PTT lamp at position 1 is dark while the same lamp at positions 2 and 3 is lighted, what is the probable fault?

2. If the ON lamp is out at the three controller's positions of the operations van, give two additional procedures that could be taken to isolate the fault.

3. Name the relays and contacts that are operating properly if you depressed the RED pushbutton during an operational test and the RED lamp operates steadily (see FO 6).

679. Specify representative trouble repair procedures for the 302 Switching Unit.

Trouble Repair. You have learned that key system relays and switches are adjusted mechanically to meet their electrical requirements. The relays in this 302 Switching Unit are kept operating or repaired in the same manner. We are not going to repeat all the information covered before in this course, and we will not copy that information found in the technical orders for the system.

Repeating the major principles that you should remember should be adequate. For example, you readjust a contact spring to a higher tension than the test value indicates. Also, since one mechanical adjustment affects other adjustments, you must observe each adjustment during the test. Use only the circuit requirement table that applies to the specific relay that you are testing and readjusting. Do not use a requirement table that pertains to another manufacturer's relay that has the same nomenclature. Move relay springs and components only after you have found that they are failing completely to perform their function. Keep relays or other apparatus uncovered only as long as necessary to complete the required maintenance.

It is evident from the preceding paragraph that relay contacts can cause circuit failure. Burnishing may be necessary when a contact is coated excessively with film or carbon. Brushing of the contact is the recommended method for removing dirt. Also, brush the remaining devices of the equipment unit if they show dirt. The brush that you use must be clean and dry. The method that you use to brush depends on the relay type. To illustrate, on wire spring relays you place the brush below open contacts and then move the brush hairs upward between the contacts. During this upward movement, you must move the brush slightly toward you and then away (sawing type movement). Withdraw the brush without cleaning contacts in another set. Repeat this cleaning several times. Now, reclean your brush in a prescribed cleaning solution, dry it thoroughly, and advance to your next set of dirty contacts. Clean normally closed contacts by inserting a toothpick between the springs. Accordingly, the contacts are held open temporarily.

Be careful not to touch relay contacts with your fingers or to touch the areas of the brush (or any other cleaning object) that is to rub the relay contact. The oil from your fingers is difficult to remove; therefore it will result in future contact failure.

Contact burnishing is done in a similar manner to the brushing in that you use a sawing motion. However, the contacts must be forced against the burnishing blade. You scratch the contacts with the rough edges of the burnishing blade. For this reason, burnishing often results in future contact failure, although it can be useful for the present time. Therefore, burnishing is normally consider as the last method of repair for a relay.

Clean the surfaces of relay pole pieces, armature, stop pins, etc., with clean paper. You press the two devices being cleaned against the paper so that there will be pressure on the paper. Withdrawing the paper will then remove the dirt. If dirt is noted on the withdrawn paper, use a second clean paper and repeat the procedure. Repeat the act until the papers show no stains. When cleaning any device within an equipment unit, examine the unit closely for loose or missing items.

Inspection and repair of the telephone for the 302 Switching Unit are done in the same manner as that for telephones in a regular installation.

After disconnecting a cable from a receptacle, place a protective cap over the receptacle (see fig. 5-7). When reconnecting a cable to an uncapped receptacle, be sure that the cable and connector are mates. For example, one cable and one receptacle at the power van are labeled REQ & ACK and are colored identically. Thus they are designed to mate. Cup and chain assemblies support some of the cable assemblies to prevent strain damage to the connectors and cables. Insure that the chain lengths are not changed when replacing a cable; or, if the chain length had to be changed during cable removal, make sure the chain is returned to the proper length after cable replacement.

Perform an operational check of the equipment following replacement of a key unit, a component, or a cable to determine that it has been correctly installed.

Exercises (679):

1. Cite two relay repair actions.

2. List two relay care actions for reducing probable future repairs.

3. Tell four procedures useful during relay repair.

4. Give actions to use with cables and cable connectors to limit damage to them.

Maintenance of AN/GTC–28 Telephone Connecting and Switching Set

YOUR SKILL IS important. To keep essential Air Force equipment working while, at the same time, keeping the costs at a minimum, you must be observant, efficient, and careful. You work with costly systems and equipment consisting mostly of small, compact electronic circuits. The delicate circuits require analysis while using sophisticated test equipment. Equipment repair requires skilled hands.

In this chapter we will describe and illustrate the AN/GTC– 28 Telephone Connecting and Switching Set (TCSS), to include system functions, operational principles, and typical maintenance activities for the system.

6-1. System Functions

The AN/GTC–28 equipment is used in conjunction with the 302 system. It provides telephone communications for the air traffic controllers at the tower and operations vans. With it, they can control and monitor 2-wire, 4-wire, and 6-wire telephone lines. The equipment comprises the position equipment group and common equipment group, which includes the power supply.

680. Identify and locate equipment in the position equipment group, and cite example controls for the units and functions of specified units or controls.

Position Equipment Group. The position equipment group has telephone sets, a ringer-telephone, and a loudspeaker. Figure 6-1 is a drawing that gives the nomenclature for the equipment in a AN/GTC–28 TCSS. The three telephone sets at the top are in the position equipment group. It should be evident that two of these sets have a dial, a handset, and lamps and pushbuttons. Hence, they compare to the telephone key sets described in the earlier chapters. The three circles in line above the dial represent a buzzer, a volume control of the buzzer, and a dimmer control for darkening or illuminating the environment of the telephone set. The TA–884 telephone set is mounted vertically and doesn't have a handset. It is shown directly connected to the ringer-telephone and loudspeaker.

The ringer-telephone is used when at least two telephone sets are connected to the same line. The loudspeaker is normally used for paging on lines 4, 5, 6, 7, 8, and 9. Two additional controls for the position equipment are also displayed in figure 6-1. These controls also change the volume of the buzzer and dim the LINE key lamps. They are represented by a small square at the base of each unit (ringer-telephone and loudspeaker).

All the position equipment is in the control tower. The telephone sets are on the controller consoles, whereas the ringer-telephone and loudspeaker are usually installed somewhere in the tower that is close to the console so that the incoming signal is noticed immediately.

Exercises (680):

1. Identify the three types of units that comprise the position equipment group.

2. To inspect the devices of the position equipment, where will you go?

3. List four devices on the AN/GTC–28 telephone sets that compare to 1A1 and 1A2 key sets.

4. What is the function of the telephone set lamps?

5. What is the function of the ringer-telephone?

681. Identify and locate equipment in the common equipment group, and cite example units and functions of specific units.

Common-Equipment Group. The common equipment group consists of the switchboard and power supply. Although they are identified as separate equipment, one rack may support both. The power supply should be the top unit of the rack and the switchboard devices are in the lowest section.

The name "switchboard" indicates the function of the equipment and correlates with the information in a previous paragraph. That is, it provides the controllers with the controls for originating and monitoring telephone calls. Scanning the front of the illustrated equipment in figure 6-1, you should note the top two sections above the meter and terminal boards. The devices of these two sections are

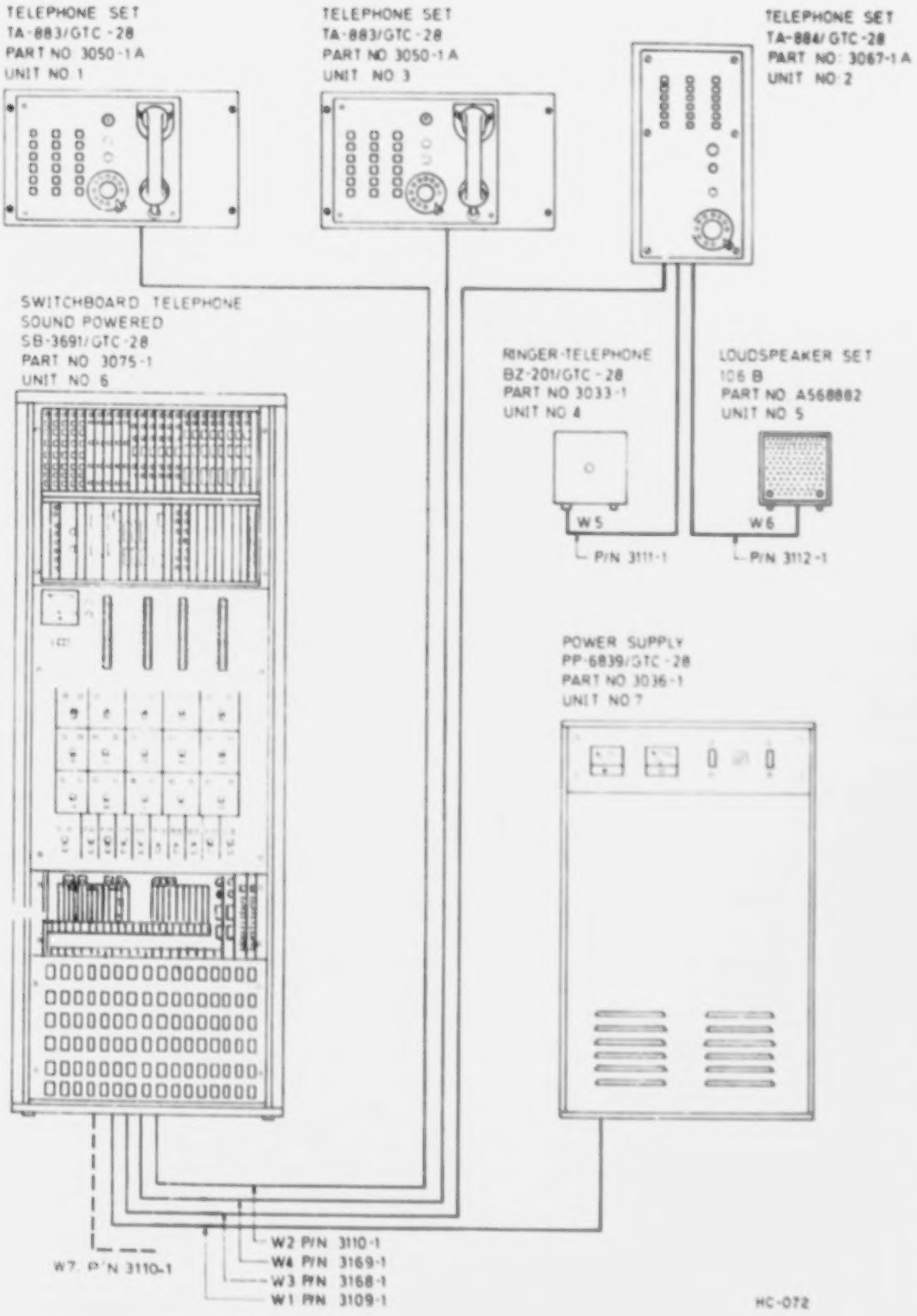

TELEPHONE SET
TA-883/GTC-28
PART NO 3050-1A
UNIT NO 1
TELEPHONE SET
TA-883/GTC-28
PART NO 3050-1A
UNIT NO 3
TELEPHONE SET
TA-884/GTC-28
PART NO: 3067-1A
UNIT NO 2
SWITCHBOARD TELEPHONE
SOUND POWERED
SB-3691/GTC-28
PART NO 3075-1
UNIT NO 6
RINGER-TELEPHONE
BZ-201/GTC-28
PART NO 3033-1
UNIT NO 4
LOUDSPEAKER SET
106 B
PART NO A568882
UNIT NO 5
W5
P/N 3111-1
W6
P/N 3112-1
POWER SUPPLY
PP-6839/GTC-28
PART NO 3036-1
UNIT NO 7
W7. P/N 3110-1
W2 P/N 3110-1
W4 P/N 3169-1
W3 P/N 3168-1
W1 P/N 3109-1
HC-072

Figure 6-1. Front view drawing of AN/GTC-28, TCSS.

printed circuit boards and associate devices. The meter measures speech power in decibels and the terminal boards are test points used for maintenance. The switches below the terminal boards permit changing the circuit impedance for the telephone lines. The second from the bottom section is another printed circuit board unit. The rectangular boxes in the lowest section of the rack represent relays. These relays are controlled by the impedance matching switches and resistors mentioned above. You should realize from this listing of components that in addition to serving as a switchboard for processing the telephone calls, this switchboard enables personnel to condition the lines it serves.

The power supply converts the standard 110–120 volts approximately 60 hertz AC to 33 volts DC and −5 volts DC for the integrated circuits, and −24 volts DC for the printed circuit boards. The two meters shown reflect the current drain and the voltage (33 volts) output of the power supply. The first device to the right of the voltmeter is the DC ON-OFF switch. Between this ON-OFF switch and the AC ON-OFF switch is the PILOT lamp, which indicates the power supply status.

The switchboard is always located at a distance from the telephone sets but no farther than 105 feet since that is the length of the interconnecting cables. In the circumstance where a power supply is separate (as illustrated in fig. 6-1), it will be no more than 15 feet from the switchboard it serves.

Exercises (681):

1. Tell two types of units that support the devices by which controller telephone calls are made most effective.

2. On which common equipment are the units of exercise 1 installed?

3. Give two functions for the switchboard.

4. What is the function of the AN/GTC–28 power supply?

5. What is a probable location for the AN/GTC–28 switchboard and power supply?

6-2. Principles of Operation

You have traced many circuits in the resident course. It should be evident now that there are many types of electronic circuits and many methods used to develop circuits which accomplish the same function. Of course, we will not consider all of the types of circuits nor the ways in which they are developed. We will only review sample transistor and logic circuits. Then we shall look at example AN/GTC–28 circuits and trace sample circuits as we consider a typical operation.

682. List three types of amplifiers and compare the common-base and common-collector amplifiers.

Amplifiers. Amplification makes possible many functions. For illustration, it provides that one circuit stage will develop a certain strength signal for a second stage, or it provides more than one circuit stage with different strength input signals, or it permits a circuit to provide an oscillating output. Let us look first at sample amplifiers.

You have seen that voltage, current, or power can be increased (amplified). The input signal strength to a transistor can be amplified as high as 1,000 times by the transistor (stage). Gain is described as the ratio between the input and output signals. For example, assume that the signal strength of the generator in figure 6-2 is .5 volt. Also, assume that the voltage at the collector connection (or load resistor) varies from 60 to 65 volts (5 volts change). As a result of these readings, we can determine that the signal strength has been increased 10 times by the transistor amplifier. The connections which make transistor amplification possible are not always the same, because we want a variety of results. Thus, we see that transistor amplifiers are classified as follows:

- Common-base amplifier.
- Common-emitter amplifier.
- Common-collector amplifier.

Common-base amplifiers. Common-base amplifiers also have been referred to as grounded base amplifiers. Figure 6-2 illustrates a common-base amplifier. This type of circuit has very low current amplification and a moderate voltage and power gain; consequently, it is not the most valuable amplification device. The circuit reveals that the input signal is applied to the emitter and that the output signal is reflected by the load resistor. If an NPN transistor had been used rather than the PNP transistor, the batteries would have been reversed, but the voltage phase relationships would remain the same. In other words, any positive change at the emitter causes an increase in voltage across the load resistor. With the preceding changes, a signal reading at the collector

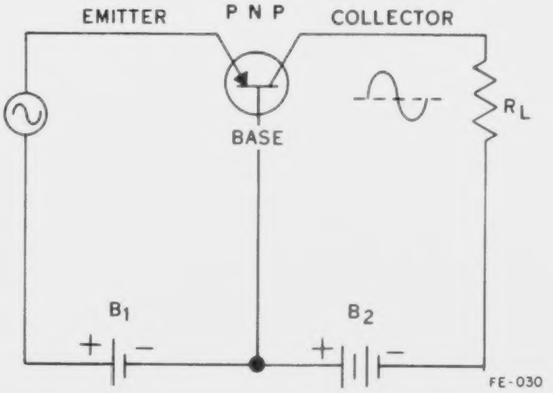


Figure 6–2. Common-base amplifier schematic diagram.

would temporarily be more positive. Vice versa, a negative signal at the circuit input results in a more negative signal at the collector output terminal.

Common-emitter amplifiers. Common-emitter amplifiers provide high voltage and power gain; thus, they are used almost exclusively in amplifier circuits. In addition, they yield a moderate current gain. Figure 6-3 shows an amplifier stage which has the emitter connected to a grounded resistor—with the base receiving a signal from a coupling capacitor. Another feature of this type of amplifier is the phase-reversal between the base and the collector. Therefore, a positive signal at the base results in an amplified negative signal at the collector. You should realize that the operating principle for this amplifier is opposite to the principle which you noted in the common-base amplifiers. Although the contrasting factors are the biasing battery and the incoming signal, the positive incoming signal for the emitter amplifier opposes the bias voltage, which is contrary to the effect you noted in the common-base amplifier. Hence, the negative signal at the common-emitter amplifier also is opposite in effect to the negative signal at the common-base amplifier. REMEMBER: Each small change to the bias voltage developed by resistors R1 and R2 results in a large change at the output of the stage. For example, 1 milliampere of change at the input can result in a 10-milliampere change at the output. Resistor R3 stabilizes the amplifier by following the changes in collector current. For example, an increase in collector current causes the voltage at R3 to increase. The reduction in potential between the base and emitter reduces the bias current, thus keeping the amplifier within its correct operating characteristic.

Common-collector amplifier. The characteristics of this amplifier are low voltage and power gain and moderate gain in current. Therefore, this amplifier is used only in special circuits. For instance, it is useful as an impedance matching unit. Figure 6-4 shows the collector connected to ground and the emitter with a positive potential when compared to the collector. Likewise, the input signal from the preceding stage is applied to the base. This amplifier stage compares with the common-base amplifier in having no reversal of phase between the amplifier input and output. It is easily seen, too, that the output signal can be taken from the emitter. A negative input signal at the base of the transistor of figure 6-4 results in an increase in current at resistor R2. Consequently, the voltage drop at the resistor is greater following the signal application than it had been before the employment of negative signal. Accordingly, the increased voltage at the resistor results in a more negative output signal. Thus, an emitter voltage change follows directly the base voltage change. We can see the basis, then, for referring to the transistor as an emitter-follower amplifier.

We have said that the common-emitter circuit is the most acceptable transistor amplifier, and that particular circuit is useful in many ways. For instance, it can be used as an IF amplifier, RF amplifier, class A amplifier, class B push-pull amplifier, or in several other applications.

Exercises (682):

1. List three types of amplifiers.

2. Give two characteristics of a common-base amplifier.

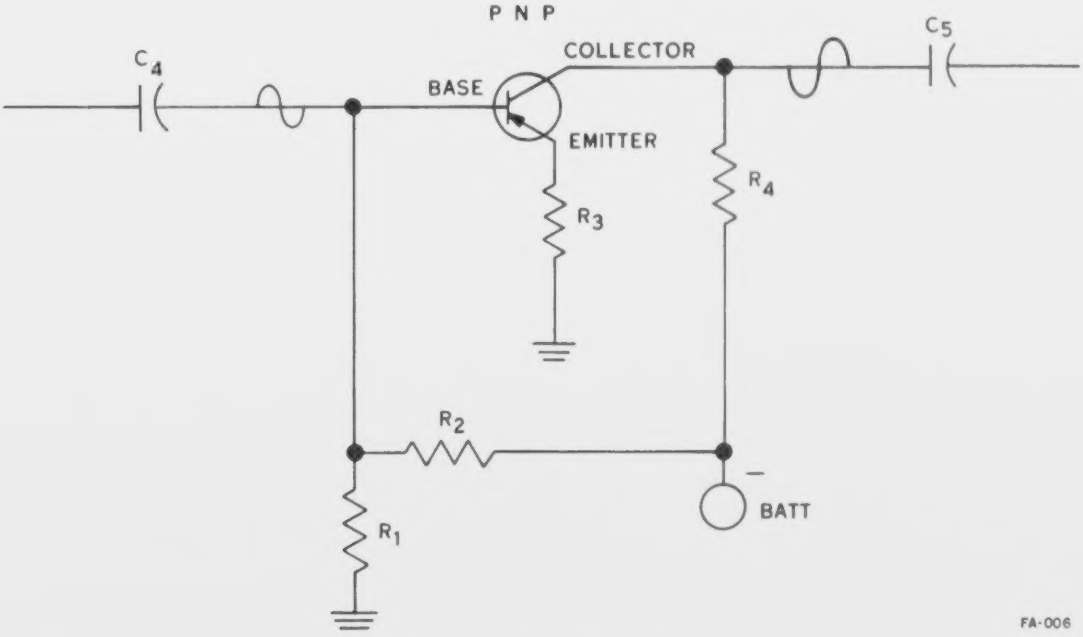


Figure 6–3. Common-emitter amplifier schematic diagram.

3. Give two characteristics of a common-emitter amplifier.

4. Compare the common-base and common-collector amplifiers.

683. Identify example logic symbols.

Logic Circuits. The switch and gate are two control devices used in an electronic circuit to permit or prohibit electron movement. Since both devices are control elements, it should cause you no difficulty when an electronic switch is called a gate. The devices that control current in logic circuits are labeled *gates*. The electronic gate is a device which has an output following the connection of one, or more than one, input. The following are included as electronic switches: the OR-, AND-, NOT-, and NOR-gates. Since the signals that operate these gates have been identified as logic, the circuits that use them are referred to as logic circuits. Such circuits have established symbols associated with them.

Logic symbols. To help maintenance technicians readily see the relationship of logic circuits in their equipment, the manufacturers provide symbols for these circuits. Figure 6-5 illustrates sample logic circuit symbols. Following consideration of these symbols, we will review illustrative logic circuits.

You may see differences in the method of illustrating a logic circuit symbol. Notice, for example, that the OR-gate is shown in two ways on figure 6-5. Normally, the manufacturer will present the symbols used with their equipment and a description of each symbol in an effort to make you aware of its meaning. Consequently, by taking a little time and becoming familiar with the manufacturers' symbols, you should be able to analyze the circuit development for the equipment.

The general symbol of H may represent a circuit which includes a resistor and a capacitor, or an inductor and a capacitor, or a resistor plus a zener diode and a parallel capacitor, etc. Hence, you can see that the circuit exemplified by the logic symbol H could be quite inclusive as well as very different. Circuit differences will be found in the equipment produced by different manufacturers. For this reason, you should realize that where a symbol is shown, you must get the associated circuit schematics and determine the differences. We know, too, that an effective circuit analysis cannot be made of any equipment from only logic symbols. The schematic diagram is the illustration that is most useful during circuit analysis.

You may wonder why there is no symbol shown in figure 6-5 for the NOT- and NOR- gates. The NOT-gate has also been referred to as a NOT AND- or NAND-gate. The NOT AND-gate circuit is an AND-gate circuit with one exception. That exception is the arrangement and connections of components. The components are so connected that there is a pulse phase inversion. (The N prefix is taken from the word "notting," which means to reverse polarity.) Accordingly, an AND-gate circuit which includes a common-base transistor would become a NOT AND-gate if a common-emitter transistor is used in the circuit. Similarly, an OR-gate circuit is a NOT OR- (NOR) gate if there is a phase inversion in the signal between the input of the transistor and the output of the transistor. Thus, the gate with the transistor connected to develop common-emitter characteristics would normally be considered as a NOT- or

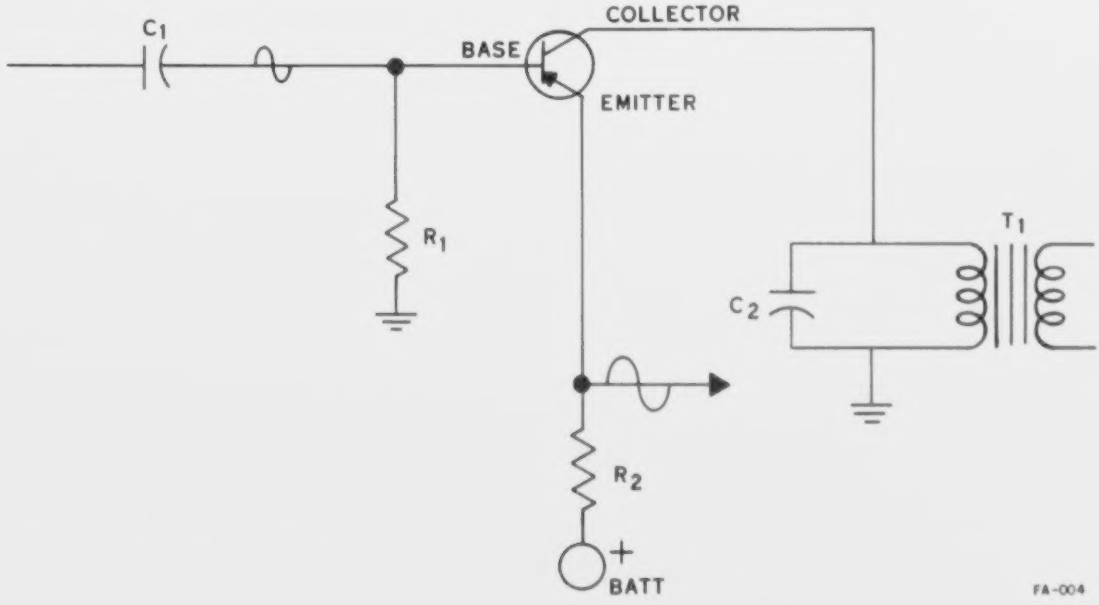


Figure 6-4. Common-collector amplifier schematic diagram.

NOR- gate circuit. You may also find the inverter symbol used to represent the NOT AND- or NOR-circuits, or a company may choose to design a symbol for its own use.

An additional identification is normally shown near each symbol. Above, below, or within the symbol, letters are placed which indicate the purpose of the circuit. For instance, an OR-gate symbol may have an EF placed above it, which distinguishes this gate as an emitter follower. Furthermore, an amplifier symbol may have included within its borders a 20 dB, which distinguishes it as a 20-decibel amplifier. Likewise, an amplifier symbol may have BF included near it or within it to reveal it as a buffer circuit. On the other hand, some companies represent the circuit in a different manner. For instance, you may find a "General" symbol with a NOR written within its borders. Hence, this company identifies the NOR-type gate circuit in this manner. Again, we remind you that it is important to determine the method by which each manufacturer illustrates logic circuits. Don't assume that each symbol shown by one manufacturer in prints will be a standard symbol for all companies.

Exercises (683):

1. What symbol of figure 6-5 could be used to represent the circuit in figure 6-3?

2. Name the two symbols of figure 6-5 that could be used with the circuit in figure 6-4.

3. Which symbol of figure 6-5 could be used to represent the circuit of figure 6-6?

4. Which is most useful when analyzing equipment trouble (symbol or circuit)?

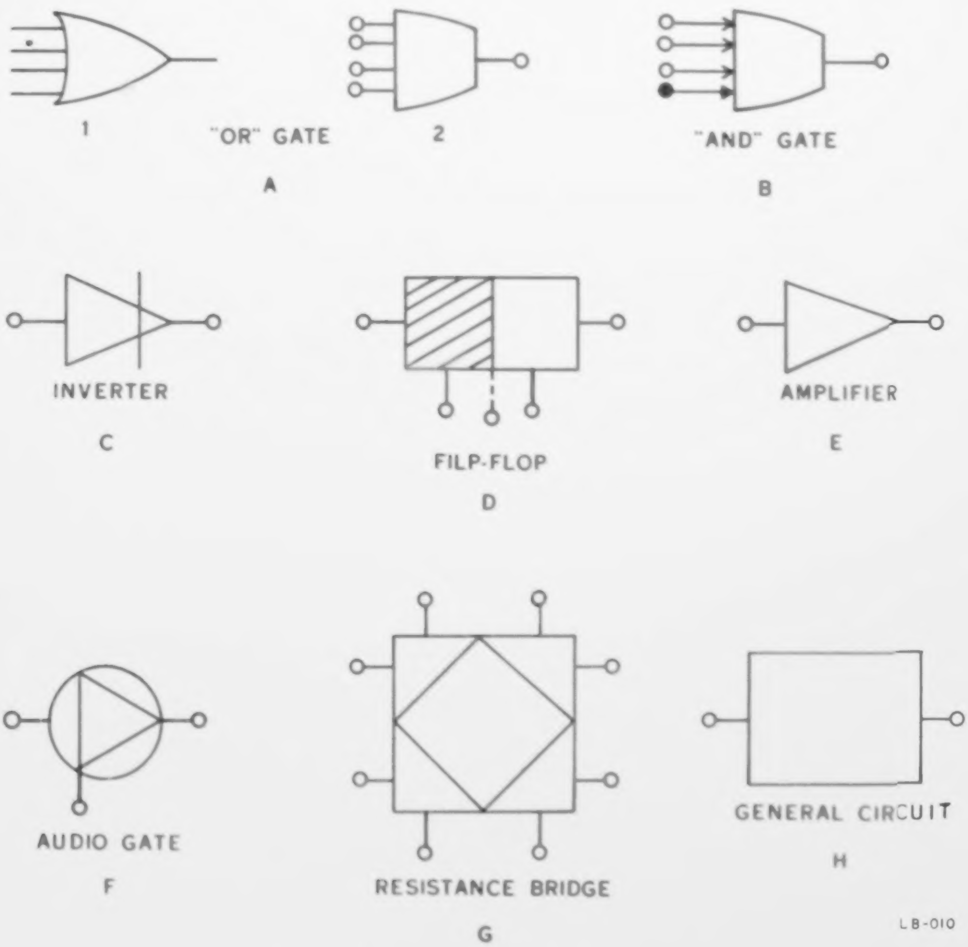


Figure 6-5. Example logic symbols for electronic circuits.

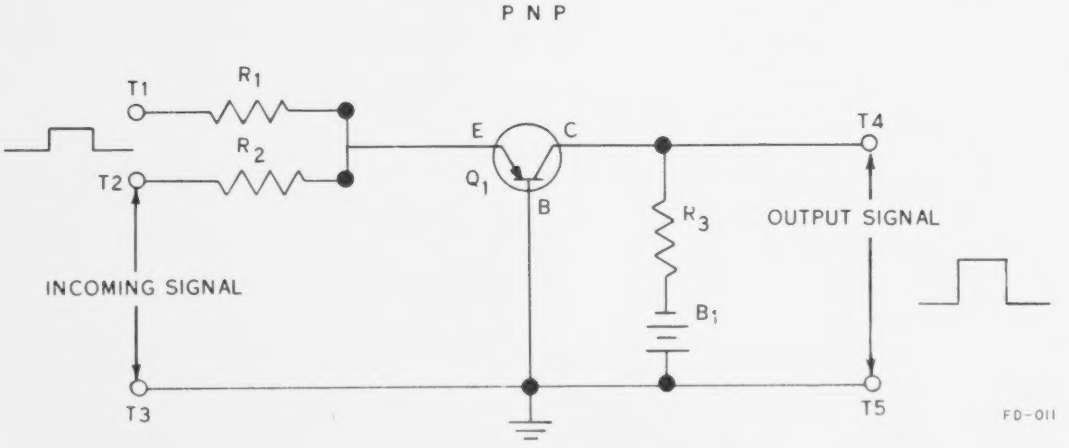


Figure 6-6. Single-transistor OR-gate with multiple input.

684. Compare and contrast logic circuits, and identify operational features for typical circuits.

OR-gate. Let's begin our discussion of an OR-circuit by repeating the definition of this type circuit. It is a circuit which has an output when one or more of the parallel input signals are connected to the input terminals. Figure 6-6 illustrates placement of the components associated with a common-base amplifier. A signal can be applied to the emitter through resistor R1 or R2, since both are connected in parallel. The transistor is cut off until the input signal is provided. This input signal has adequate strength to saturate the transistor. Moreover, the transistor is cut off again when the input level has returned to zero. It is thus obvious, as figure 6-6 reveals, that the output signal is in phase with the input signal. So the application of simultaneous signals to R1 and R2 results in a wider output signal.

Figure 6-7 shows a more complex transistor OR-gate circuit. An input signal will operate either Q1 or Q2. The output signal of both transistors is impressed across the load resistor (R5). Again, no output signal is to be seen until there is an input signal. When the signal is applied to input B, transistor Q2 operates. During this entire time, transistor Q1 remains cut off, because the conducting Q2 applies reverse bias. In short, then, only one transistor will be operating at one time. At the same time, we hope it is clearly shown that the input and output signals are in phase. This emitter-follower OR-gate of figure 6-7 has a rapid response to input signals.

NOR-gate. By comparing figures 6-6 and 6-8, you can see the difference in transistor connections for the circuits. The NOR-gate circuit has a common-emitter type transistor, which provides an inverted signal at the output. Another feature of the NOR-circuit, which is not obvious in figure

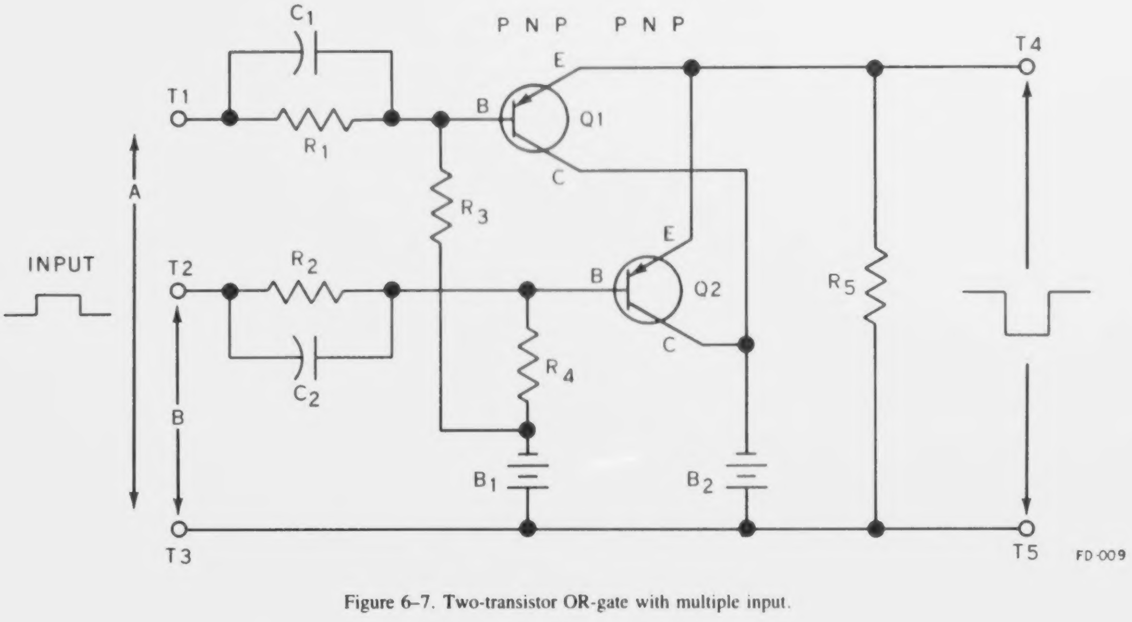


Figure 6-7. Two-transistor OR-gate with multiple input.

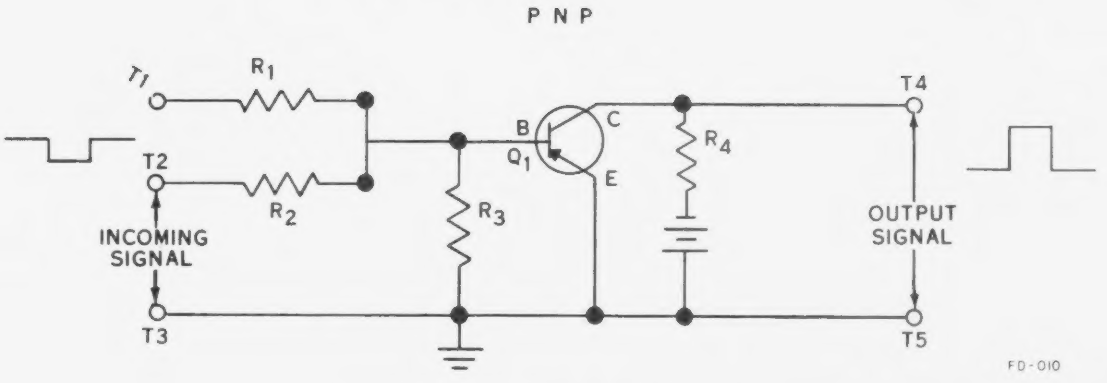


Figure 6–8. Transistor NOR-gate schematic diagram.

6-8, is that the R1 and R2 resistors have greater opposition than do the R1 and R2 resistors of the OR-circuit. It is because the input resistor R3 has been included in the common-emitter circuit that this increased resistance is required. Despite the fact that both figures 6-6 and 6-8 show us two signal source resistors, additional other resistors and signals could be included here. Let us state it again: companies will design such circuits as will serve their needs. Remember that the principle of operation for the transistor in any circuit conforms to what you have learned previously and have reviewed here, regardless of the differences in circuit construction.

Figure 6-9 illustrates a NOR-gate which has parallel-connected transistors. Comparing this latter figure with figure 6-7 reveals the out-of-phase relationship in the output signal. Common-emitter type transistors accomplish this signal inversion. The circuit operation is identical to the operation of the OR-gate circuit which we described previously. Accordingly, Q2 operates and cuts off Q1; or vice versa, operated Q1 cuts off Q2. Furthermore, a signal must be applied to input A and input B if there is to be transistor conduction. The alternate operating activity of an electronic gate circuit is also referred to as flip-flop. We can conclude that it is possible for a company to use the flip-flop logic symbol with an OR- or a NOR-gate circuit.

AND-gate. You have seen that the AND-gate has been compared with series-connected switches. Therefore, the circuit is complete when all switches are operated. Similarly, the AND-gate circuit requires an input signal at each input terminal if the circuit is to operate as desired. In this type of circuit it is also necessary that the transistor conduct fully (at saturation) or be cut off. AND-circuits may be designed to provide a variety of functions. For example, a company may develop the AND-gate so that all transistors must operate if the input signal is to activate the equipment. You may see this effect used in "checking" a circuit; the circuit is tested when all of the signals are provided at the input. If the proper signals fail to arrive, then the circuit is considered to have failed the "check." Counting can also be done by an AND-gate. In this function, a single output signal activates the equipment, provided that the number of input signals conforms to the number of transistors included in the circuit.

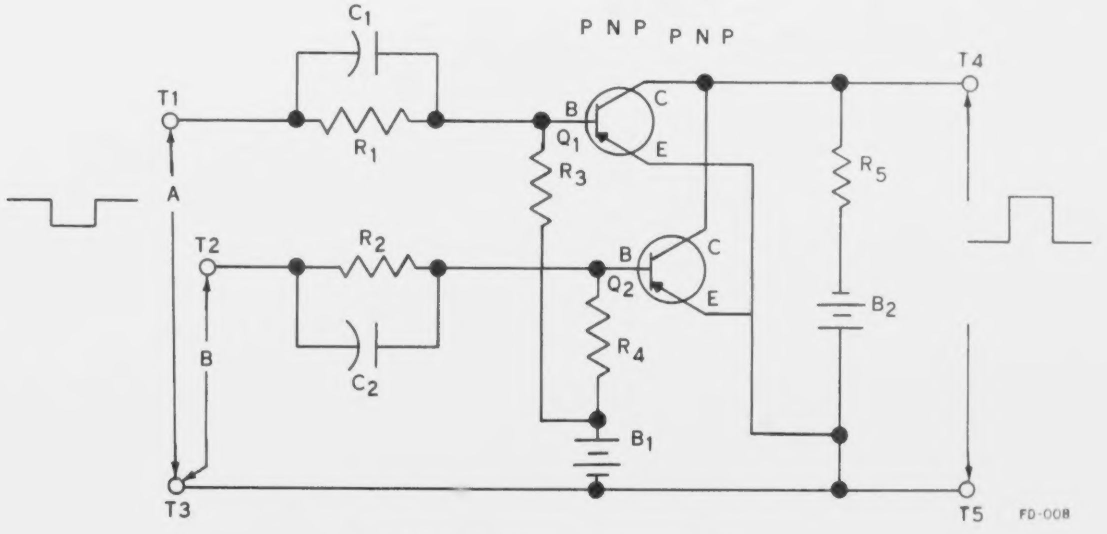


Figure 6–9. Parallel-connected transistor NOR-gate.

Thus, five incoming signals may activate a circuit which, in turn, operates a device that represents a 5. Conversely, the circuit may be so designed that all transistors must operate if the input signal is to interrupt or release a circuit.

Comparing figure 6-10 with the OR-gate of figure 6-7 reveals two differences. The bias battery (B1) has been reversed, so that negative battery is connected to the base of Q1 and Q2. Also, the incoming signal must be positive if the transistors are to conduct. This figure correlation discloses, then, that the same circuit can be used as an AND-gate, OR-gate, NOT AND-gate, and NOR-gate. By changing a minimum number of connections, you determine the gate circuit type.

NOT AND-gate. We have seen that this gate circuit is an AND-gate circuit with a phase inversion (negative feature). Consequently, there is no need to describe it. Because the use of the common-emitter transistor is the NDT AND-circuit, the inverted output signal is amplified more than is the output signal of the AND-circuit.

Gate circuits may be combined in (1) series, (2) parallel, or (3) series-parallel. Accordingly, they respond like series switches or parallel switches.

The amplifier and logic circuit theory we just covered is brief. Although these illustrated circuits may not be like the circuits of the AN/GTC-28, the theory applies to all electronic circuits. Hence, it should help you when tracing the circuit operations of the AN/GTC-28 equipment.

Exercises (684):

1. Which symbol of figure 6-5 could be used to represent the circuit of figure 6-10?

2. Compare the input and output signals for the circuit of text figure 6-8.

3. Name the actions of the transistors of the circuit in figure 6-9 which provides the output signal.

4. Identify two requirements for a transistor gate circuit.

685. Specify devices operated, connections made, or probable results of an action in a line key.

AN/GTC-28 Circuits. How well the AN/GTC-28 equipment is able to perform depends upon the successful operation of its electronic circuits. A 100% successful operation is achieved only if each device performs all its actions accurately. Your understanding of the circuits and subsequent maintenance of them may determine the accuracy of these actions. We shall consider briefly a key operating (ring-out) signal, a ring-in signal, and audio signaling.

Line key. Assuming that the No. 1 line key on telephone set 2 is depressed, we recall that this action places ground on a contact of the key. Figure 6-11 is a functional diagram useful for tracing this circuit. You can see this line key at the right of the figure and just below the logic lamp circuit.

The ground potential is also connected to jack 1, plug 2 for the telephone set and is further connected to jack 3, plug 4 for the switchboard by means of cable W3. Tracing to the left, you should arrive at terminal D6 of terminal board 2 on the cross connection frame (A6). This D6 terminal is

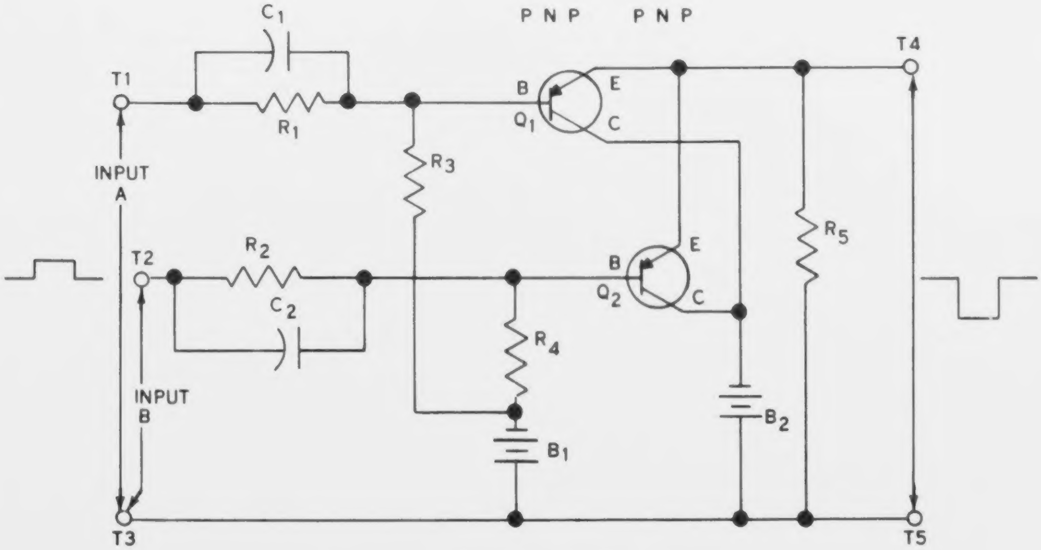


Figure 6-10. Parallel-connected transistor AND-gate.

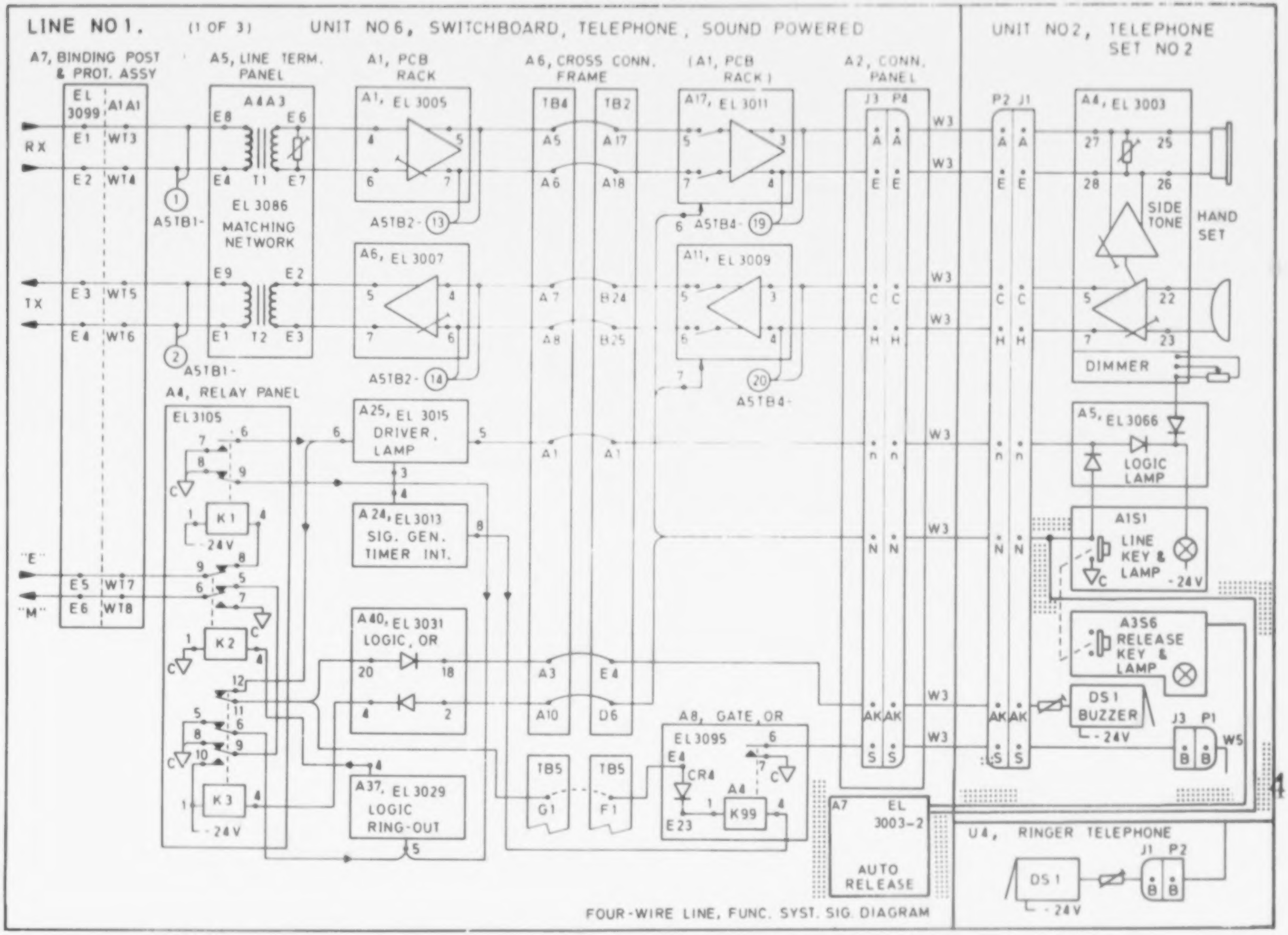

LINE NO 1.
(1 OF 3)
UNIT NO 6, SWITCHBOARD, TELEPHONE, SOUND POWERED
UNIT NO 2, TELEPHONE SET NO 2
A7, BINDING POST & PROT. ASSY
A5, LINE TERM. PANEL
A1, PCB RACK
A6, CROSS CONN. FRAME
(A1, PCB RACK)
A2, CONN. PANEL
EL 3099
A1A1
A4A3
A1, EL 3005
TB4
TB2
A17, EL 3011
J3
P4
P2
J1
A4, EL 3003
RX
TX
E1
E2
E3
E4
E5
E6
WT3
WT4
WT5
WT6
WT7
WT8
E8
E6
E4
T1
E7
E9
E2
E1
T2
E3
EL 3086
MATCHING NETWORK
A5TB1-
A5TB2-
A5TB4-
A6, EL 3007
A11, EL 3009
A5
A6
A7
A8
A17
A18
B24
B25
W3
W5
SIDE TONE
HAND SET
DIMMER
A4, RELAY PANEL
EL 3105
K1
K2
K3
-24V
"E"
"M"
A25, EL 3015 DRIVER, LAMP
A24, EL 3013 SIG. GEN. TIMER INT.
A40, EL 3031 LOGIC, OR
A37, EL 3029 LOGIC RING-OUT
A1
A3
A10
E4
D6
TB5
G1
F1
A8, GATE, OR
EL 3095
CR4
A4
K99
E23
A7 EL 3003-2 AUTO RELEASE
A5, EL 3066 LOGIC LAMP
A1S1 LINE KEY & LAMP
A3S6 RELEASE KEY & LAMP
DS1 BUZZER
J3 P1
AK
S
B
U4, RINGER TELEPHONE
DS1
J1 P2
FOUR-WIRE LINE, FUNC. SYST. SIG. DIAGRAM

Figure 6-11. Four-wire line schematic diagram-Line 1.

cross-connected to terminal A10. Tracing from A10 we see that the ground potential will also be at logic A40. This logic then connects a potential to relay K3 of the switchboard. Hence, it operates to connect a −24 volt DC potential to contact 9. The potential is thereby connected to the M lead.

Exercises (685):

1. Since the ringout circuit includes logic A40, what device is operated within the unit to complete the K3 relay circuit?

2. Identify the switchboard relay contacts that complete the M lead circuit.

3. Name two other devices that usually operate following depression of a telephone line key.

686. Cite connections that complete the RING-IN circuit, devices operated, or probable results of connections made.

Ring-in circuit. Since relay K1 is shown with −24 V connected to terminal 1, it should be seen that the incoming signal must be a positive potential. This potential enters on the E lead. The operated K1 relay connects ground to contact 6 and to the lamp driver. This ground potential at terminal 6 is applied to the emitter of transistor Q2. Figure 6-12 illustrates this transistor in the lamp driver schematic diagram. Tracing from the base of Q2 you will see that it is connected by way of R2 and CR2 to the collector of Q1, which is in the flasher circuit. The flasher pulses affect Q1, thus are also at the base of Q2 (awaiting the ground from relay K1). Since we have noted this ground potential at the emitter, the flashing pulses now are also applied to terminal 5 of the lamp driver. Figure 6-11 shows that from terminal 5 the pulse passes through the cross-connecting frame and the A2 connection panel of the switchboard, through cable W3, to the telephone set. The pulses activate the logic circuit for the lamp; hence the telephone set lamp flashes.

A second circuit for the ground from relay K1 needs also to be traced. Tracing from contacts 6 & 7 of relay K1, follow the wire down to contact 12 of unoperated relay K3. This ground potential causes logic A40 to provide the operating potential for the buzzer at the telephone set. This latter potential is traced through the cross-connect frame, through the A2 Comm Panel, cable W3 and to the buzzer, which has −24 VDC at its second terminal for the winding. Hence the buzzer rings.

Exercises (686):

1. Identify the relay contacts that complete the RING incoming circuit to the line 1 relay in the switchboard.

2. List the electronic devices in the lamp driver unit that complete the RING-IN circuit between relay K1 contact 6 and frame A6.

3. What is the condition of Q2 with the relay K1 operated?

687. Given an audio signal situation, determine actions that occur or results that follow.

Audio signal. Having seen the flashing lamp and depressed the key, the controller acknowledges the call. As a result, he or she can be heard by the call originator. Again, let's look at figure 6-11 and start tracing at the transmitter.

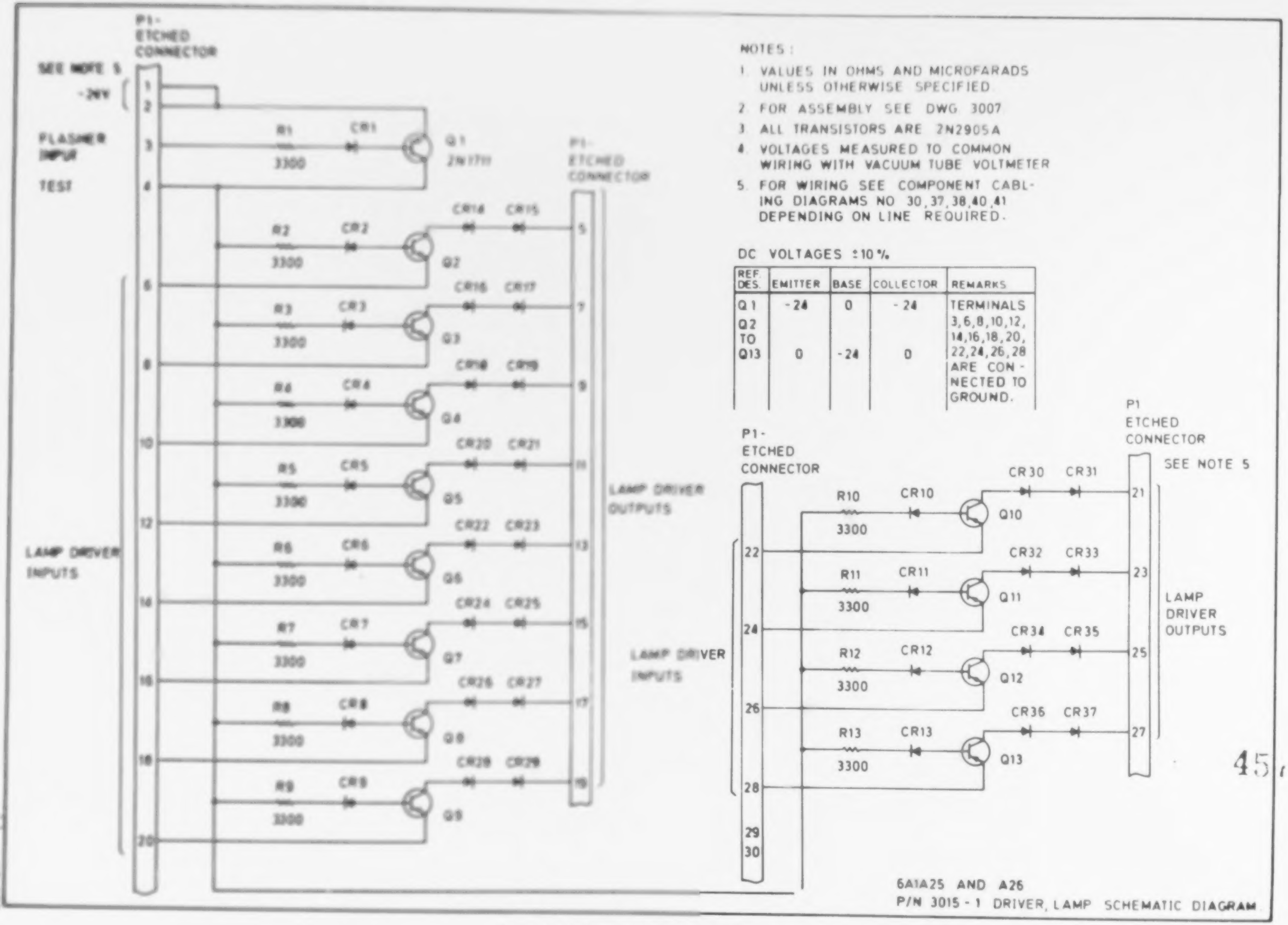
The voice signal of the controller is amplified in the A4 amplifier and is then carried by a pair in cable W3 to the A2, COMM Panel at the switchboard. The voice then passes to the A11 Electronic Switch. Figure 6-13 is the schematic diagram of this electronic switch. We traced the circuit of figure 6-11 to terminals 3 and 4. These terminals are shown in figure 6-13 to be connected with a differential amplifier and two emitter followers. Again, comparing the two schematics, the audio output for line 1 passes out through terminals 5 and 6. To get to these latter terminals from the emitter followers, the voice current passes through the devices (diodes, resistors, and capacitors) identified as switch 1.

The amplified voice signal from this switch goes through the A6 cross-connecting frame to enter the audio frequency amplifier (A6). This unit has differential amplifiers that compare with those of figure 6-13. Hence, the voice signal enters terminals 4 and 6, is amplified by transistors controlled by the regulating resistors, after which the amplified signal leaves terminals 5 and 7.

The voice signal now enters the A4A3 network of transformers. (See fig. 6-11.) Transformer T2 improves the voice signal quality by matching the impedance of the outgoing line with the impedance of the switchboard equipment. The voice signal next goes to the binding post and protector assembly and then out to the interconnecting cable (not shown in fig. 6-11).

You should recall that the voice message spoken by the controller should also be heard by him. Looking again at the first amplifier in A4 that we traced after leaving the transmitter, you should see it connected to a second amplifier listed as SIDETONE. This sidetone amplifier, then, provides an adequate signal to his own receiver.

The receiving circuit for the voice signal compares with the transmit circuit. Of course in this case, you begin tracing at the binding post and protector circuit for the switchboard,


P1-
ETCHED
CONNECTOR
SEE NOTE 5
-24V
FLASHER
INPUT
TEST
LAMP DRIVER
INPUTS
LAMP DRIVER
OUTPUTS
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
3300
CR1
CR2
CR3
CR4
CR5
CR6
CR7
CR8
CR9
CR10
CR11
CR12
CR13
CR14
CR15
CR16
CR17
CR18
CR19
CR20
CR21
CR22
CR23
CR24
CR25
CR26
CR27
CR28
CR29
CR30
CR31
CR32
CR33
CR34
CR35
CR36
CR37
Q1
2N1711
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
1
2
3
4
5
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NOTES :

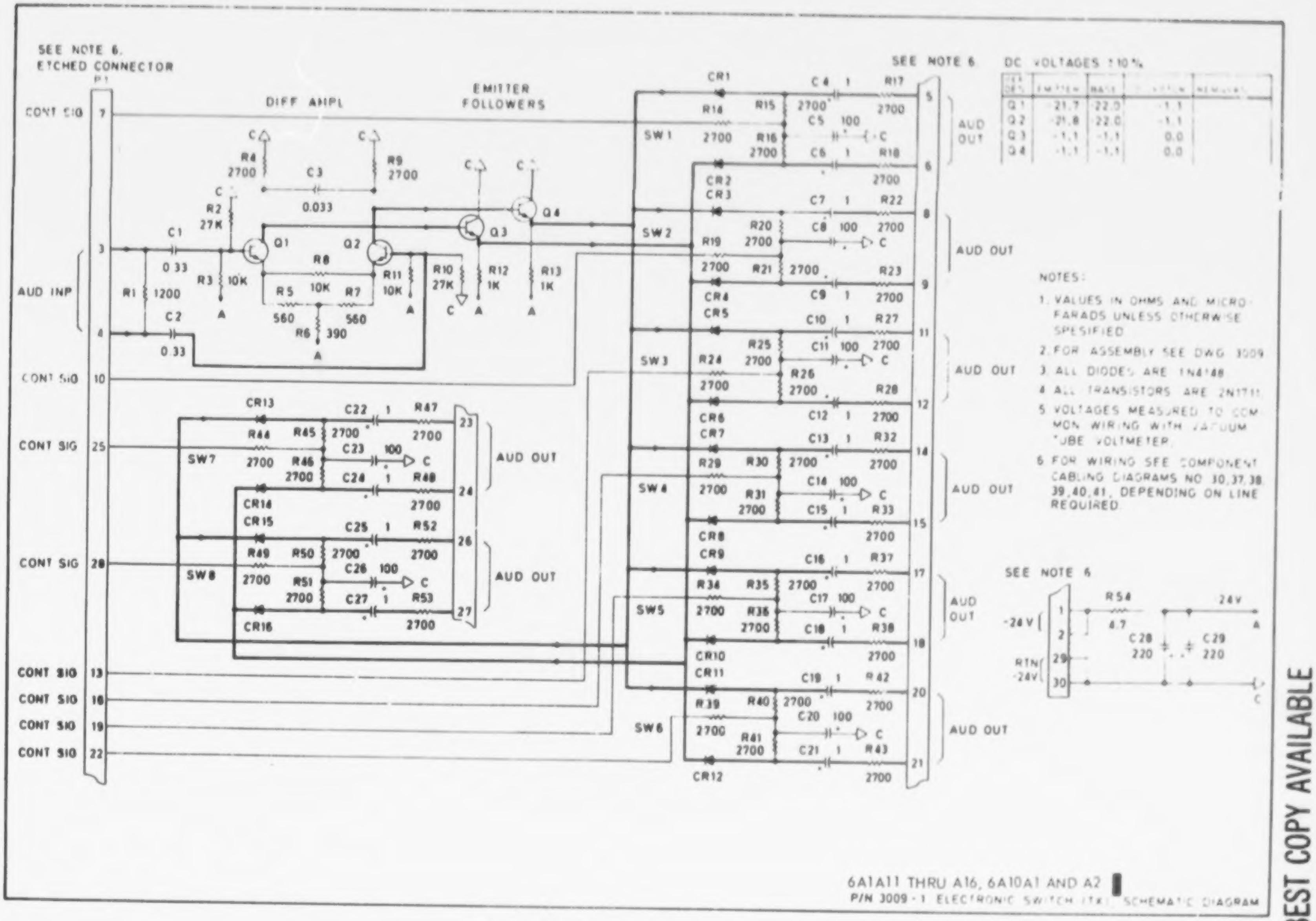
1. VALUES IN OHMS AND MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. FOR ASSEMBLY SEE DWG 3007.
3. ALL TRANSISTORS ARE 2N2905A
4. VOLTAGES MEASURED TO COMMON WIRING WITH VACUUM TUBE VOLTMETER
5. FOR WIRING SEE COMPONENT CABLING DIAGRAMS NO 30, 37, 38, 40, 41 DEPENDING ON LINE REQUIRED.

DC VOLTAGES ±10 %

REF. DES.	EMITTER	BASE	COLLECTOR	REMARKS
Q 1	- 24	0	- 24	TERMINALS 3, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28 ARE CONNECTED TO GROUND.
Q 2 TO Q13	0	- 24	0	

6A1A25 AND A26
P/N 3015 - 1 DRIVER, LAMP SCHEMATIC DIAGRAM

Figure 6-12. Lamp driver schematic diagram.


SEE NOTE 6.
ETCHED CONNECTOR
P1
CONT SIG
AUD INP
CONT SIG
CONT SIG
CONT SIG
CONT SIG
CONT SIG
CONT SIG
CONT SIG
DIFF AMPL
EMITTER FOLLOWERS
R4 2700
R9 2700
C3 0.033
R2 27K
C1 0.33
C2 0.33
R1 1200
R3 10K
R5 560
R6 390
R7 560
R8 10K
R11 10K
R10 27K
R12 1K
R13 1K
Q1
Q2
Q3
Q4
SW1
SW2
SW3
SW4
SW5
SW6
SW7
SW8
AUD OUT
SEE NOTE 6
R54 4.7
C28 220
C29 220
24V
-24V
RTN -24V

DC VOLTAGES ±10%

REF DES	EMITTER	BASE	COLLECTOR	REMARKS
Q1	-21.7	-22.0	-1.1	
Q2	-21.8	-22.0	-1.1	
Q3	-1.1	-1.1	0.0	
Q4	-1.1	-1.1	0.0	

NOTES:

1. VALUES IN OHMS AND MICRO-FARADS UNLESS OTHERWISE SPESIFIED
2. FOR ASSEMBLY SEE DWG 3009
3. ALL DIODES ARE 1N4148
4. ALL TRANSISTORS ARE 2N1711
5. VOLTAGES MEASURED TO COMMON WIRING WITH VACUUM TUBE VOLTMETER.
6. FOR WIRING SEE COMPONENT CABLING DIAGRAMS NO 30,37,38, 39,40,41, DEPENDING ON LINE REQUIRED.

6A1A11 THRU A16, 6A10A1 AND A2

P/N 3009-1 ELECTRONIC SWITCH (TK), SCHEMATIC DIAGRAM

Figure 6-13. Electronic switch schematic diagram.

BEST COPY AVAILABLE

then go through the matching network, into another amplifier (A1). This is likewise a differential amplifier that strengthens the signal. Your tracing next takes you through the cross-connecting frame to the following amplifier (A17). In this amplifier, the signal follows through switch 1 of eight switches and through another differential amplifier. The remainder of the circuit you can now trace easily since it is the same as those already traced. Remember, the final device to see in this circuit tracing is the receiver for the telephone set *handset*.

Exercises (687):

1. Tell the type switch represented as contacts in the A11 block (fig. 6-13) that passes the voice signal during transmission.

2. Identify the switch type represented as contacts in the A17 block (fig. 6-13) that passes the voice signal for the handset receiver.

3. What electrical condition results at the differential amplifier when the telephone set operator begins talking?

4. Name the electrical unit that balances incoming and outgoing circuits for best signal quality.

688. Trace a schematic diagram of central office dial line and determine similarities and differences to four-wire diagram.

Central office dial line. Comparing figures 6-14 and 6-11 shows the handset circuits are identical except at the line terminal panel. Other differences to be noted in the switchboard are the ring detector of the line terminal panel and the LOGIC HOLD unit in the PGB rack. At the handset, the additional controls shown are the hold key and the dial.

Since the line key operation and the transmitter and receiver circuits for line 10 are the same as for line 1 described above, we are not reviewing them again. We shall look only at the circuit actions following an incoming call for line 10 and placing this call on HOLD temporarily.

Again looking at the RX identification at the upper left in the schematic (fig. 6-14) we trace through made contacts 8 & 9 and 11 & 12 for relay K26 of the switchboard relay panel to the ring detector. This detector connects ground to relay K27 of the relay panel. Thus, it operates. As a result, the ground at its operated contacts activates the lamp driver and the SIG GEN TIMER to flash the lamp and operate the buzzer at the telephone set. This situation compares to the incoming signal for line 1.

The attendant in wanting to answer a second call now depresses the HOLD key. As a result, he or she connects ground potential to the LOGIC HOLD circuit board. This circuit includes jack 1 plug 2 (pins g), cable W3, jack 3 plug 4 (pins g), and terminals D22 and E7 of the cross connect frame. The ground operates the logic gate in turn, to, pass the wink signal from the SIG GEN TERM unit out on terminal 13, through cross connection terminals E2 and A10, through the switchboard A2 comm panel, through cable W3, into the handset lamp logic unit. This unit then enables the lamp to wink at the same rate as designated by the SIG GEN TIMER equipment at the switchboard.

As noted before, a second operation of the line key restores the lamp to a steady illumination and releases the LOGIC HOLD circuit.

Looking at the dial circuit, note that the operated dial opens one circuit while making a second circuit. These circuits are completed by terminals of the A6, cross connect frame, and made contacts of operated relays K29 and K26. Remember, the operated dial pulses a specific number of times as determined by the attendant's selection. These pulses are then passed through the relay contacts and connected to the central office line for seizing the central office equipment.

Exercises (688):

1. Give a matching network difference for lines 1 and 10.

2. Indicate the similarity for relays K1 and K27 of the relay panel.

3. Compare the operating difference for relays K26 and K27 at the relay panel.

4. Contrast the operations for relays K26 and K29.

689. Trace a selective signal schematic diagram and determine connections, actions, or operational results for specific situations.

Selective signaling. Another sample circuit trace we are including in the operation principles for the AN/GTC-28 system is that of selective signaling. Figure 6-15 illustrates the connections and components for the typical line circuit developed for selective signaling.

Assuming again that you have depressed the line key, the result is a ground potential connected to the switchboard equipment. In this case, the ground is applied to relay K17 on the relay panel. The operated K17 relay makes three sets of contacts, of which only two are useful for now. The made contacts complete a circuit for the A34, KEYER, unit. This circuit includes the made contacts at the dial on the telephone set.

460

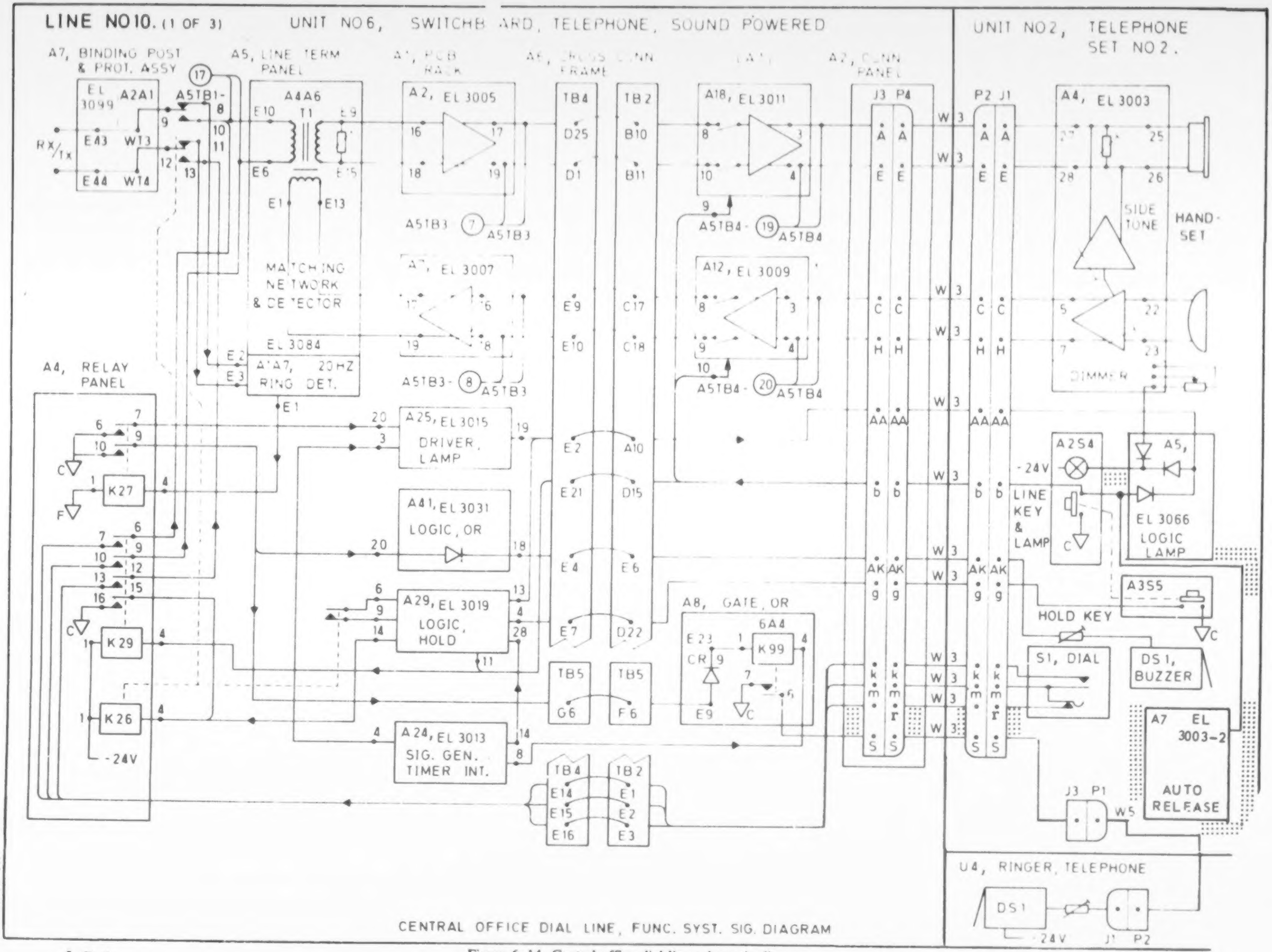

LINE NO10. (1 OF 3)
UNIT NO6, SWITCHBOARD, TELEPHONE, SOUND POWERED
UNIT NO2, TELEPHONE SET NO2.
A7, BINDING POST & PROT. ASSY
A5, LINE TERM PANEL
A2, CONN PANEL
EL 3099
A2A1
RX/TX
E43
E44
W13
W14
A5TB1-
A4A6
T1
E10
E9
E6
E15
E1
E13
MATCHING NETWORK & DETECTOR
EL 3084
A4A7, 20HZ RING DET.
A2, EL 3005
A5TB3
A7, EL 3007
A5TB3-
TB4
TB2
D25
D1
B10
B11
E9
E10
C17
C18
A18, EL 3011
A5TB4-
A5TB4
A12, EL 3009
J3 P4
P2 J1
W3
W5
A4, EL 3003
SIDE TONE
HANDSET
DIMMER
A4, RELAY PANEL
K27
K29
K26
-24V
A25, EL 3015 DRIVER, LAMP
A41, EL 3031 LOGIC, OR
A29, EL 3019 LOGIC, HOLD
A24, EL 3013 SIG. GEN. TIMER INT.
E2
A10
E21
D15
E4
E6
E7
D22
TB5
G6
F6
A8, GATE, OR
6A4
E23
CR9
K99
E9
E14
E15
E16
E1
E3
A2S4
A5,
-24V
LINE KEY & LAMP
EL 3066 LOGIC LAMP
A3S5
HOLD KEY
S1, DIAL
DS1, BUZZER
A7 EL 3003-2 AUTO RELEASE
J3 P1
U4, RINGER, TELEPHONE
DS1
-24V
J1 P2
CENTRAL OFFICE DIAL LINE, FUNC. SYST. SIG. DIAGRAM

Figure 6-14. Central office dial line schematic diagram.

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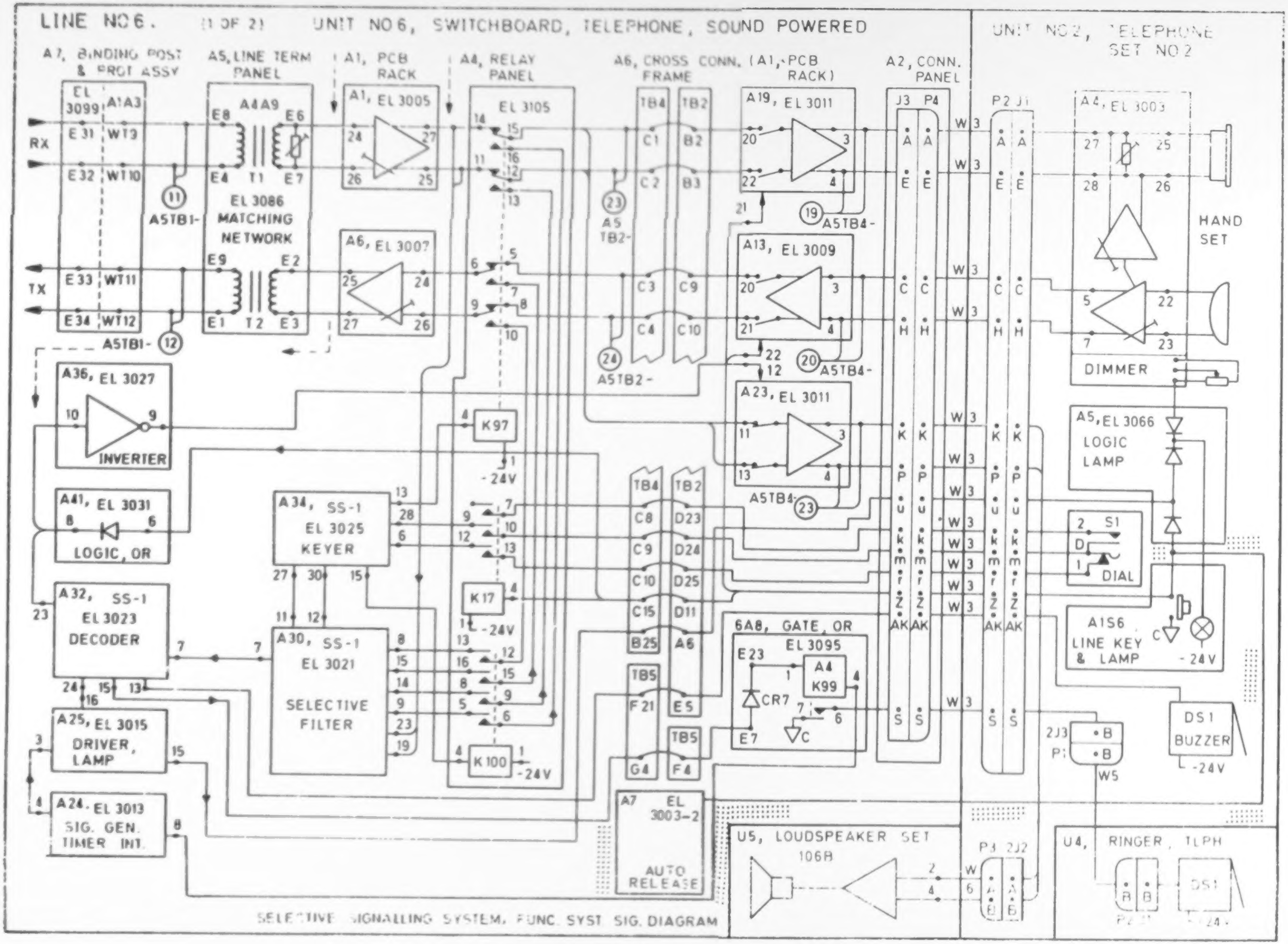

LINE NO 6.
(1 OF 2)
UNIT NO 6, SWITCHBOARD, TELEPHONE, SOUND POWERED
UNIT NO 2, TELEPHONE SET NO 2
A7, BINDING POST & PROT ASSY
A5, LINE TERM PANEL
A1, PCB RACK
A4, RELAY PANEL
A6, CROSS CONN. FRAME
(A1, PCB RACK)
A2, CONN. PANEL
EL 3099
A1A3
A4A9
RX
TX
E31 WT9
E32 WT10
E33 WT11
E34 WT12
E8 E6 E4 T1 E7
E9 E2 E1 T2 E3
EL 3086 MATCHING NETWORK
A5TB1-
A1, EL 3005
A6, EL 3007
EL 3105
TB4 TB2
C1 B2 C2 B3 C3 C9 C4 C10
A5 TB2-
A19, EL 3011
A13, EL 3009
A23, EL 3011
A5TB4-
J3 P4
P2 J1
A E C H K P u k m r Z AK S
W3
A4, EL 3003
HAND SET
DIMMER
A5, EL 3066 LOGIC LAMP
S1 DIAL
A1S6 LINE KEY & LAMP
-24V
DS1 BUZZER
A36, EL 3027 INVERTER
A41, EL 3031 LOGIC, OR
A32, SS-1 EL 3023 DECODER
A25, EL 3015 DRIVER, LAMP
A24, EL 3013 SIG. GEN. TIMER INT.
A34, SS-1 EL 3025 KEYER
A30, SS-1 EL 3021 SELECTIVE FILTER
K97
K17
K100
TB4 TB2
C8 D23 C9 D24 C10 D25 C15 D11 B25 A6
TB5 F21 E5 G4 F4
6A8, GATE, OR EL 3095
E23 CR7 E7
A4 K99
A7 EL 3003-2 AUTO RELEASE
2J3 P1 W5
U5, LOUDSPEAKER SET 106B
P3 2J2
U4, RINGER, TLPH
DS1
SELECTIVE SIGNALLING SYSTEM, FUNC. SYST. SIG. DIAGRAM

Figure 6-15. Selective signal schematic diagram.

The KEYER now provides a two tone (2400–2600) hertz signal to the selective filter unit. Also, it completes the operating circuit for relays K97 and K100. As a result, these relays operate.

The two tones leave the filter unit, pass through the relay contacts of relays K97 and K100 into the line amplifier A6. After amplification, it enters the matching network transformer. As noted before, the signals are coupled by this transformer to the line.

An incoming two-tone signal for this line enters the A5 line term panel matching transformer, goes through the amplifier in the PCB rack, and then goes to the selective filter. This two-tone signal becomes DC pulses for use by the decoder. If the pulses are accepted by the decoder, its output is amplified in the lamp driver. You should remember from our previous tracings that the lamp driver signal operates the lamp at the telephone set after passing through the cross connect frame, the switchboard and telephone set jacks and plugs, and the interconnecting cable W3.

A second circuit to trace from the decoder includes the inverter amplifier, the electronic switch and mixer (A23), jacks and plugs for the switchboard and telephone set, and the 106B loudspeaker. This circuit permits loudspeaker monitoring of the originator's call.

Exercises (689):

1. List the contacts for relays K97 and K100 that carry the two-tone signal to the A6 line amplifier.

2. Identify the KEYER terminals that connect ground potential to operate the K97 and K100 relays.

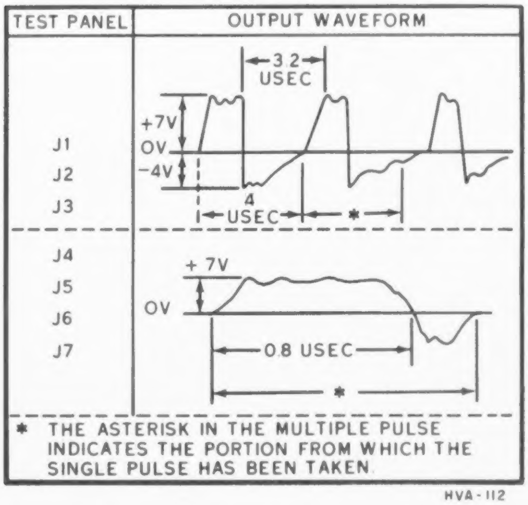

TEST PANEL
OUTPUT WAVEFORM
J1
J2
J3
3.2 USEC
+7V
OV
-4V
4 USEC
*
J4
J5
J6
J7
+ 7V
OV
0.8 USEC
*
* THE ASTERISK IN THE MULTIPLE PULSE INDICATES THE PORTION FROM WHICH THE SINGLE PULSE HAS BEEN TAKEN.
HVA-112

Figure 6–16. Output waveforms, example.

3. Name the audible supervisory unit that operates when ground is connected to detector terminal 15 by its operated gate.

6-3. System Maintenance

Manufacturers use several methods to help you test their equipment. One company has installed jacks and listed voltages to be read at these jacks. These jacks may be the output test point for a part of one circuit or for a complete circuit. Another company has provided test points and listed decibel measurements that should be found at these points.

690. Interpret sample test illustrations.

Figure 6-16 shows a test result that you may see on equipment jacks. In this example, voltage sine waves are shown. At jacks 1, 2, and 3 there is a signal voltage output which goes from 7 volts positive to 4 volts negative. The positive peak of the signal exists for .8 microsecond and the negative peak of the sine wave lasts for 3.2 microseconds. Thus, the complete cycle is 4 microseconds. Having tested jack 3 for this signal, you progress to jack 4. You should now see that the signal is different. The positive 7-volt peak is still .8 microsecond in length, but it reaches the peak at a delayed rate and also falls to zero at a slower rate. The negative alternation also has delays for its peaking and return.

You use an oscilloscope to test at each jack from 1 through 7. This may not always be necessary. You may have tested jack 1 and observed the signal, after which you test jack 3. A good signal at this last jack means that the circuits feeding jacks 2 and 3 are effective. Now, a test of jacks 4 and 7 can provide a similar result. A good signal from both means that all seven circuits are operating. If jack 4 shows the desired signal and jack 7 does not, we recognize that the trouble is in circuit 5, 6, or 7.

Figure 6-17 is another illustration of an oscilloscope signal (oscillograph). In this case, a sine wave is not clearly evident. The three lines (pulse pictures) in the center of the screen are on the base line and the lower three lines are the

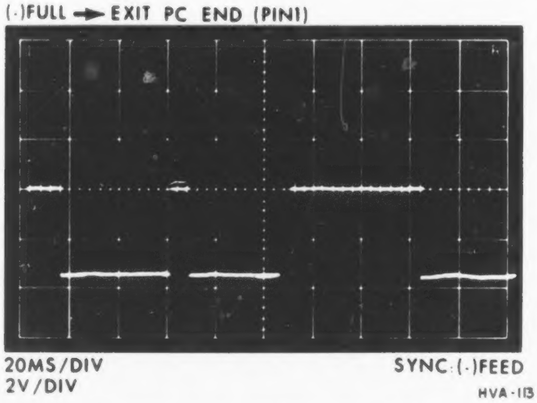


Figure 6–17. Partial oscillograph face with view of feed returns.

result of applying negative input signals to an electronic circuit. The signal is picked up by connecting leads of the oscilloscope to equipment test points. From each test point, you should go to a subsequent test point and look for its signal. Again, you compare the signal which you see to a signal illustrated in a manual for the equipment. Figure 6-18 is a portion of a page of an equipment manual showing test points (TP). This page is used in conjunction with oscilloscope signals which should be noted during your test. By comparing the information to the left of the arrow from TP 1 on figure 6-18 with the information above the block of figure 6-17, you can see that both read, "(–) full exit print cycle end." On figure 6-18, you can see two test points that have positive input signals, TP 4 and TP 6; the remainder are negative input signals.

Exercises (690):

1. Give the potential for jack 2 of the test panel at time 10 microseconds (See fig. 6-16).

2. Comparing the signals of figure 6-17, which is the most positive signal(s)?

3. Identify the probable test points at which the signals of exercise 2 were measured.

691. Interpret an example technical order performance test procedure and cite a required standard.

The information of this objective varies from that of objective 690 in that a vacuum tube voltmeter, an oscillator, and a test box are used for the test. The principle noted above still applies in that you check the equipment using specified test points, looking for an established standard measurement, and do the testing using a step-by-step procedure.

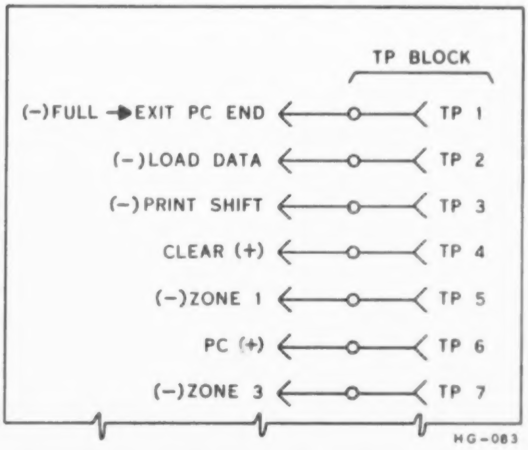


Figure 6–18. Partial listing of test points for oscilloscope.

Figure 6-19 is a page from the technical order for the AN/GTC–28. You should note that the preliminary instructions tell the seven steps that are required to prepare for the subsequent measurement. Accordingly, you plug the card into the test box, connect the voltmeter and oscillator to this box, install two resistors to specific terminals, and ground another terminal. Also, it describes three measurements for you to make.

The first measurement requires you to adjust the oscillator attached to terminals 3 and 4 for 1,000 hertz and observe the VTVM. If the circuit is good, the voltmeter will show between 0 and 2 decibels at .77 to .84 AC volts. Note that this has been the audio measurement.

Exercises (691):

1. What card is to be inserted into the test box as the first procedure?

2. Give the resistance to be provided for the test and the numbers for the steps in which you install them.

3. When you vary the oscillator input frequency from 50 Hz to 10,000 Hz, what should be the frequency response by the TX card?

692. Given the test point references, determine the test reading for a specified test or the location to go for making the test.

We have noted terminals used as test points and looked at a technical order. The same technical order also lists test point references and indicates the measurement to look for. Figure 6-20 has two example test points for lines 1 through 10. Accordingly, test point 1 for line one is at terminal board 1 terminal 1. The test reading should be 0 decibels to –15 decibels. The test measurement at test point two for line ten is –5.5 decibels and is checked at terminal 7 of terminal board 3.

Exercises (692):

1. Tell the reading to expect at test point 2 for line 6.

2. Where shall you look to test the decibel reading for test point 1 for line 8?

PERFORMANCE TEST OF ELECTRONIC SWITCH (TX), P/N 3009-1, Circ. Diag. EL 3009

PRELIMINARY INSTRUCTIONS:

a. Plug TX-switch card into test fixture as shown in Fig. 5-6.

b. Apply -24 VDC and ground to the test fixture terminals 1 and 30.

c. Connect voltmeter between terminals 5 and 6 (balanced output).

d. Connect a 3.3 Kohm, 5% resistor between terminals 5 and 6.

e. Connect audio oscillator across terminals 3 and 4 (balanced input).

f. Connect a 820 ohm, 5% resistor between terminal 7 and -24 VDC (terminal 1).

g. Connect terminal 7 to ground (terminal 30).

TEST NO. 1 AUDIO MEASUREMENT

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
1A	Adjust oscillator to 0.44 Vrms at 1,000 Hz	Terminals 5 and 6	None	VTVM: between 0 and 2 DBM, 0.77 to 0.84 VRMS.

TEST NO. 2 FREQUENCY RESPONSE

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
2A	Maintain 0.44 Vrms from oscillator. Vary the input frequency continuously from 50 Hz to 10,000 Hz	Terminals 5 and 6	None	The -3 dB points relative to 1,000 Hz will be outside the 200 Hz to 4,000 Hz

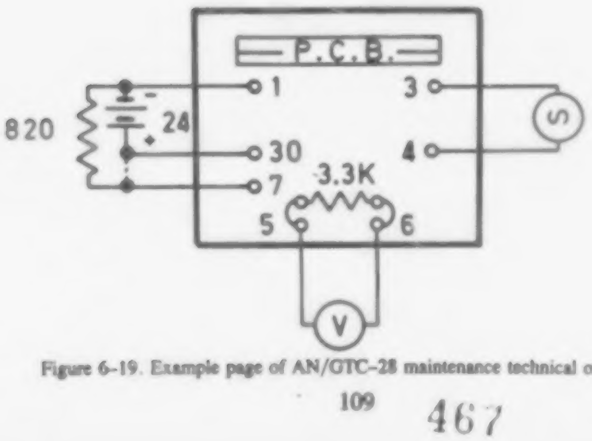
TEST NO. 3 SWITCH ISOLATION MEASUREMENT

h. Remove ground from terminal 7.

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
3A	Adjust to 0.44 Vrms on the input from oscillator	Terminals 5 and 6	None	At least 50 DBM below nominal output

NOTE: Check the remaining 7 identical switches on the PCB per Table 5-13 and see schematic diagram EL 3009

TEST EQUIPMENT CONNECTION
FOR 3009-1
Tests 1A, 2A, 3A.



HC-077

Figure 6-19. Example page of AN/GTC-28 maintenance technical order.

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	TP-1	TP-2
	0dB - 15dB	-5.5 dB
Line 1	TB-1-1	TB2-13
Line 2	TB1-3	TB2-15
Line 3	TB1-5	TB2-17
Line 4	TB1-7	TB2-19
Line 5	TB1-9	TB2-21
Line 6	TB1-11	TB2-23
Line 7	TB1-13	TB3-1
Line 8	TB1-15	TB3-3
Line 9	TB1-16	TB3-5
Line 10	TB1-17	TB3-7

Figure 6-20. Sample test point references.

693. Identify two actions for an operational test for an AN/GTC-28 telephone set.

The operational test is also useful for the AN/GTC-28 as it was for the key systems. To do this test, ring the subscriber and talk to him or her. Then ask for a return call. The return call will let you observe the lamp and ringer or buzzer operations. Remember, the lamp should flash until you depress the line key; then it should be steady. If the 106B speaker is connected for paging, it should have voice sounds following operation of the associated controls.

Exercises (693):

1. What operational action tests the transmission quality of the telephone set?

2. What operational action tests the supervision devices of the telephone set?

UNIT	SYMPTOM	FAULTY PART/SUBASSEMBLY	PROBABLE UNIT
TS	RLS key on all TSs releases only keys 13 - 16	Fuse 7A5F1 on power supply (BATT)	
TS	Line key lamp doesn't light	Replace lamp	Lamp driver 3015-1
TS	No receiver output at handset	Handset earphone	
TS	No line key lamps will light	Dimmer transistor Q1	
SB	Key lamps don't wink	Signal Generator Timer	LOGIC HOLD
SB	No ring out	Heat coil	
SB	No ring out	LOGIC, RING OUT	LOGIC, OR
SB	Ringer-Telephone doesn't work	GATE, OR (6A8)	Relay K99

Figure 6-21. Example trouble tracing chart.

694. From a fault tracing chart, determine probable trouble and repair for specified trouble symptom.

It should now be evident that trouble location in the AN/GTC- 28 compares to determining troubles in all electronic equipment. You look for the trouble symptom, analyze the circuit for probable reasons for the symptom, and test or replace suspect components. Figure 6-21 has a sampling of trouble symptoms for equipment, suspect part or subassembly, and probable unit to replace. To illustrate, if a telephone line lamp doesn't light, the most likely fault is the lamp. If the lamp replacement still results in a dark lamp, the lamp driver assembly should be tested or replaced.

Exercises (694):

1. Identify a probable fault if all line key lamps fail to operate.

2. Give three units that could be replaced to correct the symptom ''No ring out.''

695. Specify typical maintenance tasks, publications used when doing maintenance, and a maintenance supervision control fixture.

Maintenance may include servicing, repair, and replacement of equipment components. Also, the equipment may be inspected and tested for its performance. The work may be done periodically; yet it must be done on a ''when required'' basis rather than on the the basis of 'tinkering for learning how the equipment was put together.' Since technical orders and work cards list maintenance procedures for many telephone systems and 3- and 5-level specialists do the maintenance, we need not give detailed instructions here for performing maintenance.

Analysis experience is best gained through practice on the job. There is no assurance that what is now considered best cannot be improved. With an effective inspection system, through accurate analysis, and by means of continuous examination of reports, you can provide an efficient workcenter. Efficiency results when the work conforms to directives or established standards. If standards are not available, you should develop some for your assigned system.

You should insure that communications are adequate between the workcenter and work-load control to provide efficiency in the maintenance program. Make certain, too, that information about the equipment condition is posted on the status board. A properly maintained status board helps workload control, you, and your associates to see the condition of the equipment and the system because it shows the outages and a reason for the outage.

Remember: Success depends on cooperation and coordination among people. Make your information available to those with whom you work. Build from the knowledge that you acquire. Working for success should be your immediate goal. Continue your study of electronic principles and telephone equipment to prepare yourself for the opportunities that will be offered you in the future.

Exercises (695):

1. Tell two maintenance tasks that relay adjustment could be considered part of.

2. What is a very probable maintenance task with printed circuit boards?

3. What is the Air Force publication that lists step-by-step maintenance procedures for most system's equipment?

4. What additional publication to that of exercise 3 should you consult when preparing to do maintenance on the AN/GTC-28 TCSS?

5. Name the organizational maintenance fixture that aids the commander in controlling the people and their service.

CHAPTER 7

Telephone Equipment Management

GOOD MANAGEMENT insures reliable communications. The effective coordination among Air Force communications activities and commercial sources provides consistent equipment compatibility although the new equipment varies greatly from the older equipment. Further, the equipment of the future will likewise differ from the present systems, and good management will plan so that the compatibility among systems and reliable communications will continue to exist.

This chapter will briefly cover leased and Government owned subscriber service, coordination, survey and on-premise inspections, and service order preparation and record maintenance for leased service.

7-1. Leased Subscriber Service

It is Government policy to use the communications systems that are the most reliable, yet are the least expensive. As a result, many of the communications systems now providing service to the Air Force are leased from communications service contractors.

696. Identify typical leased telephone services.

Types of Services. Commercial inward and out-dial calls for subscribers are a regular service provided for reducing the need for operators (expensive telephone service). A second dial service is AUTOVON, which is limited to class A (telephones having access to central office and toll trunks) and class C telephones (providing access to Government stations for transacting Government business). AUTOVON out-dial is only possible with the class A telephones whereas dialing-in is possible with both the A and C telephones. We mentioned expensive operator service above; yet, operator service at switchboards is also required. Switchboard services include connections to AUTOVON, city, intercity, and foreign exchange trunks. Preferential services may include key personnel and command post exclusion, and security police and fire department access. Security police and fire department personnel need this type service since many of their calls are emergency type. Private line and key system installations are supplemental services for contractor consideration.

Exercises (696):

1. List three regular type leased subscriber services.

2. Give two preferential type leased subscriber services.

3. Identify a commonly authorized supplemental leased telephone service.

697. Identify factors to consider when planning a telephone service contract, and cite tasks that provide support for a proposal.

Planning. Leased telephone planning may be of two types—planning for service for an installed system and planning for a proposed sytem.

Since the installed system already has cable and attachments installed, you plan for their regular maintenance, proposed modifications, and expansion. The plan should include a schedule for accomplishment of the work, an estimate of the costs for the year, and a forecast of probable changes.

Planning for a proposed leased system compares in that you prepare a cost estimate. However, this estimate is more extensive because you should plan for at least a 3-year period. This planning may require development of specifications that show the present cable route and cable assignment and the proposed necessary changes to them. If the cables are in full use, new cables will be required and new maps must be developed. The plan will also show present telephone service requirements and any proposed relocations and expansion. The specifications show the main stations, extension stations, lines, trunks, and special service connections and installations. Also, a time-phase schedule should be developed to show the contractor accurate need dates.

The information used by the planners is provided by base personnel who determine the needs of all the base organizations, and who then assemble and summarize this information. An inventory of the on-base telephone equipment and circuits is additional information provided to the planners. Personnel may also study other bases that are structured similarly to compare the requirements and costs. The base personnel also will study the base facilities for license, lease, and easement requirements. This is done because if the contractor attaches equipment to Government supporting structures, the Government must give permission by way of one of these elements.

Exercises (697):

1. Identify two factors for each yearly plan with a current leased system.

2. Tell two tasks to do when developing the plan of exercise 1.

3. List three factors involved when planning a proposed contract.

4. Give two tasks required before proposing a new lease.

698. Cite leasing considerations and factors.

Leasing Considerations. Leasing arrangments for communications services are included in a negotiated service contract agreed to by an Air Force representative and by the telephone company. Of course, there are the services to be provided; for instance, the number of switchboard lines, the dial, and AUTOVON connections that were mentioned earlier. The key systems requirements are an additional service to be considered. Another element to be considered when preparing the contract is the service charges.

Many types of charges are considered during the contract negotiations. The following are samplings of charges included in the leasing arrangement. Tariff charges are a fixed monthly assessment. These charges are state regulation established rates for all telephone companies. Minimum service charges are considered when special construction is required to provide the requested service. This charge is also a monthly assessment. The Installation Plus Carrying Charge is a lump sum charge made to the contractor as compensation for the cost of nonrecoverable facilities.

Air Force personnel verify cost figures by comparing them with other contracts and determine if they are reasonable. This task also includes a study of the engineering plan and a comparison of the plan with the cost estimates for technical and rate structure accuracy.

Exercises (698):

1. Identify a leasing consideration that relates to the telephone systems equipment.

2. What is the leasing factor that includes tariff and minimum service?

3. Mention two factors to note when verifying a lease contract.

699. Identify operations management procedures and cite a probable reason for doing example procedures or typical factors to note when doing them.

Management Procedures. During your study of this chapter it should have been noted that good management is necessary if there is to be reliable communications and a minimum of cost to the user. One management procedure that you may do is "control calls."

Control of calls. The telephone control officer and/or his or her staff must review the telephone call records to be sure that only authorized people are making official long distance calls. In regard to these calls, the office must also verify the charges for them. In case of unauthorized calls, the office investigates to identify the caller and disciplines the person involved. Periodically, the office also verifies that the trunk circuit recording equipment is as specified in the engineering plan and continues to be accurate.

The telephone control office studies the work requests for validity and then prepares work orders. It verifies that the work done is as requested. It inventories reports to be sure that they are being completed correctly and that the information is accurate (equipment identity and charge rates etc.). To illustrate, the office must study the cost records every 4 months to be sure that class B telephone users are charged at the proper rate and that the monthly bills show this charge. This review is coordinated with the accounting and finance office. Further, the office studies all bills for validity.

The control office must study the prescribed operating procedures to insure that they are accurate, necessary, and are being followed. To illustrate, all toll calls must be recorded. The record must show an identifying number for the call. This number may consist of a date number, a cost number, a called station number, and/or a calling station number.

The control office must inventory or assist in inventorying the communications equipment annually to identify excess equipment or an overdue repair of equipment. Remember: If there is excess equipment or if equipment has been out of service for a long period, then it is probable that the lease is unnecessary and should be renewed at a lesser cost.

Processing bills. The base communications officer must study the monthly bills from the telephone contractor to be sure that they are accurate. Information to be examined includes: (1) local service charges from the beginning of a billing period; (2) Additional equipment charges, such as telephone move disconnection and reconnection; (3) billing discrepancies; (4) interzone (bulk-message) costs; and (5) long distance calls and costs. To verify the charges, the office should compare dates, credits, and charges on the monthly bill with credits and authorizations.

The errors or omissions are noted and then revealed to the contractor. If a large number of errors are found, all billing copies will be returned to the contractor. The contractor will review the deficient bill and discuss the differences with the communications officer until some agreement or adjustments are approved by both. Then, a corrected bill will be submitted. The control office, in turn, prepares and sends a prescribed voucher to the finance and accounting office as an indication of the bill's approval. This voucher is a standard form whose blank areas are mostly self-explanatory. The blanks requiring accounting classification data and other comparable specifications are described in the applicable regulation. One copy of this form and the contractor's billing are kept at the communications office until the bill is paid.

Exercises (699):

1. Identify two telephone operations management procedures.

2. List three call control procedures.

3. Why should the telephone control office inventory the telephone equipment and have a traffic study annually?

4. What method(s) should the communications officer use to verify that monthly bills are accurate?

5. Give three things to note on a telephone company bill.

6. Tell two procedures used by the communications officer to authorize a telephone bill payment.

7-2. Government-Owned Telephone Facilities

The Government owns telephone facilities if it is much less costly to the Government or if there are no commercial service facilities available, such as at a base that is located in an isolated area. Another reason for Government-owned facilities is military requirements that are beyond the normal commercial services, thus is mission essential type service. Yet, even with leased telephone equipment and circuits, the Government usually owns many of the supporting structures. Consequently, it will receive compensation while at the same time be charged for the contractor provided service.

700. Identify telephone, telephone attachments, or services for which the Government is compensated.

We have mentioned that when Government facilities are used in connection with a private telephone system, a license is required for the Government to receive adequate compensation. Example agreements for which the Government is compensated are coin-box telephones, attended telephone centers (switchboards), cable pairs, poles, crossarms, and conduits. Most licenses are revocable, thus can be easily changed or dropped. Also, the compensation to the Government is often a form of credit.

The Government is also compensated for telephone service it provides with its own system. For example, for hospital key personnel and patient private service, telephone service for contractors, telephones for labor unions, and for the American Red Cross and commissary telephone service. Rates charged are assessed monthly and are the same for leased and Government-owned systems. They are set rates and are shown in an applicable regulation. The charges vary according to class of service.

Exercises (700):

1. Name two telephone equipment units that require a Government license.

2. Identify two base organizations who normally pay telephone charges to the Government.

701. Cite example policies and requirements for Government-owned telephone systems.

All installations, expansions, or system replacements must be approved by headquarters personnel. The telephone class of service ratio will be standard at each installation. The ratio shall be 40 percent class A to 60 percent class C. Since class B service is the unofficial type, headquarters establishes its criteria and approves installation of these telephones. AUTOVON supervision is also the responsibility of headquarters personnel. An example policy is that AUTOVON service must be graded as a percentage of call attempts blocked. The Air Force goal for incoming calls is that 95 out of 100 calls should be completed.

A second Air Force headquarters policy states that Air Force Communications Command (AFCC) will conduct semiannual analyses on AUTOVON access lines to insure that the grade of service goal is being met. AFCC will make the decisions by which a deficiency is overcome, such as add access lines change circuitry or equipment. The installation communications officers are designated by headquarters to see that traffic studies are done semi-annually. Further, they will be sure that only the persons with a need for making long distance calls have a phone with access to AUTOVON.

Exercises (701):

1. What is the policy that states that 85 out of 100 outgoing calls must be satisfactorily completed?

2. What is the policy that identifies tasks for the commands and organizations?

3. List two requirements of the local communications office concerning AUTOVON service.

7-3. Coordination, Survey, and On-Premise Inspections

Managing cannot be effective without knowing the people whom you supervise and the other people with whom you work. You must have their confidence if they willingly work for you and with you. Coordination, then, is one of your tasks.

Before a telephone system installation can begin, a survey team is sent to the location. This preinstallation survey will show site conditions, support availability, security clearance need, certification status, and other requested factors, requirements, or actions that may affect the installation.

Associated with the survey is the ON-PREMISE inspection. It compares with the survey, and you may do both at the same time or do both when performing other inspections.

702. Specify typical coordination actions required of a telephone equipment technician and the people or organizations with whom to coordinate.

Coordination. Coordination with personnel of other fields is necessary to provide a minimum of interruptions during installation or rehabilitation. Consultation is necessary with utilities, outside plant, and base materiel personnel who must be available at specific times. The Air Force civil engineering group must have the building in good condition before you begin your project. If CE Group personnel work while you are installing or modifying equipment, they could cause dust to cover equipment devices or damage the equipment in other ways. Ventilating, air conditioning, and heating must also be provided before you begin. The outside plant personnel should have the required cables ready for connection. The materiel section will provide tools, filing cabinets, and other necessary building furnishings.

As a part of management of the telephone control office, team members may constantly seek your advice on how to properly monitor and survey a system. As a team chief, you must be able to give advice correctly. Also during the proce You must make decisions on how best to control the manpower and materials that you have available to insure that you meet the time schedule allotted to complete the job. One means of controlling manpower is to insure that all workers know exactly what job they are to perform. If they are briefed thoroughly on individual duties at the start of each duty day, then wasted time and duplication of effort can be avoided. Also, it is extremely important that shift supervisors brief each other on what projects they have accomplished during their duty hours. You must deal fairly with your supervisors and your subordinates.

Fairness involves several factors, including being impartial and avoiding favoritism. Often being fair, in terms of being impartial, is difficult. There may be individuals in the telephone shop who are exceptionally well qualified, are well mannered, and measure up to every standard you've set. It wouldn't be fair to these individuals to ignore them, but it also wouldn't be fair to them or their coworkers to constantly use them openly as examples of the standards you've set. What you must do is recognize an individual's effort and praise him or her in a manner that does not offend or diminish the self-confidence of others.

Controlling material also plays an important part in insuring that you meet your time schedule. We suggest that you devise a simple supply system so that you can account for all materials to make them quickly available to your team when they need them.

Customer education is another coordination task. To make customers aware of the service available and to get them to accept the limitations and restrictions, too, you must use techniques that don't agitate nor are overbearing. The customer learns by reading published information, by seeing films, and by attending briefings and/or formal training classes that you organize or conduct.

Also, it often requires tact to reject an installation or extension request because the customer felt the request was adequately justified when submitting it. Thus, you must be able to reason with that person, give good reasons for the rejection and do it without showing impatience or anger.

Exercises (702):

1. Identify two coordination activities required when preparing to install a key telephone system.

2. Name three people with whom you will coordinate.

3. Identify three coordination tasks for a team member.

703. Indicate the purpose for a survey and list disclosures to be noted.

Survey. A survey may be made to determine if the equipment is performing adequately and if there are potential problem areas. The survey may include only a representative of the equipment of the total system.

The equipment is observed to see that it performs in accordance with its technical specifications, if it is being properly maintained, and if the maintenance reports show the work being done and the frequency of the maintenance.

Exercises (703):

1. Tell the purpose of a telephone equipment survey.

2. What should a survey disclose?

704. Identify the equipment included in an on-premise inspection and state when and how it is accomplished.

On-Premise Inspections. An annual on-premise inspection is made of all leased and Government-owned telephone equipment except for class B station equipment. This inspection allows you to inventory the assigned equipment to be sure that everything is available and usable. To show that the inspection was completed and what was observed, you complete specified forms. The forms used to record a Government-owned equipment inventory differs from that used to record a leased equipment inventory. One form for Government-owned telephone recording is the AFTO Form 121, Telephone Equipment Line Record. The applicable leased equipment record is AF Form 1077, Individual Telephone Service Record. Record preparation will be disclosed in the next objective.

Exercises (704):

1. Name the telephone equipment to be inspected on premise.

2. What is the maximum time permitted between on-premise inspections?

3. Give two requirements for an on-premise inspection.

7-4. Service Order Preparation and Record Maintenance

The many forms for recording telephone service actions have appropriate spaces for entering the required information. Since each form has a regulation that tells how to complete it, we shall not duplicate the applicable description. We will only review types of records and mention typical types of information to be included. Then, we will describe example tasks used to keep these records accurate and usable.

705. Identify example telephone records and types of information to be placed on them.

Since records show what equipment is installed, where it is placed, and how it was done, they are very necessary to the maintenance people for keeping the equipment operating. The records are also useful for planning for future operations.

We have already noted that records for Government-owned telephone systems are often different from those for leased telephone equipment. You should be aware that for both types of records there are forms for requesting work to be done; for example, relocating telephones or installing an extension telephone. The form used may be identified as a work order or as a service order or request. Having completed the requested work, the equipment change or installation must then be entered on a permanent record. This latter form may be identified as a service record, as a line record, or as an equipment record. We earlier spoke of long distance callers needing to be identified to insure that they were authorized personnel. Hence, there must be a form for recording these callers and the station and/or person called. Another form is the telephone trouble log that is a record of equipment outage reports. Remember, this is only a sampling of records which you may use or maintain.

The information on these records can be identified as technical and managerial. The technical information should be that which identifies the equipment, cable, pair, terminals, etc. Figure 7-1 is a sample form that shows blocks in the center of the page containing this identification. The managerial information blocks of figure 7-1 include TO, FROM, Billing Address, Service Order No, Title and Signature of Approving Official, Installer, and Records Posted (personnel).

Exercises (705):

1. Tell the type record to use when requesting replacement of a defective drop wire.

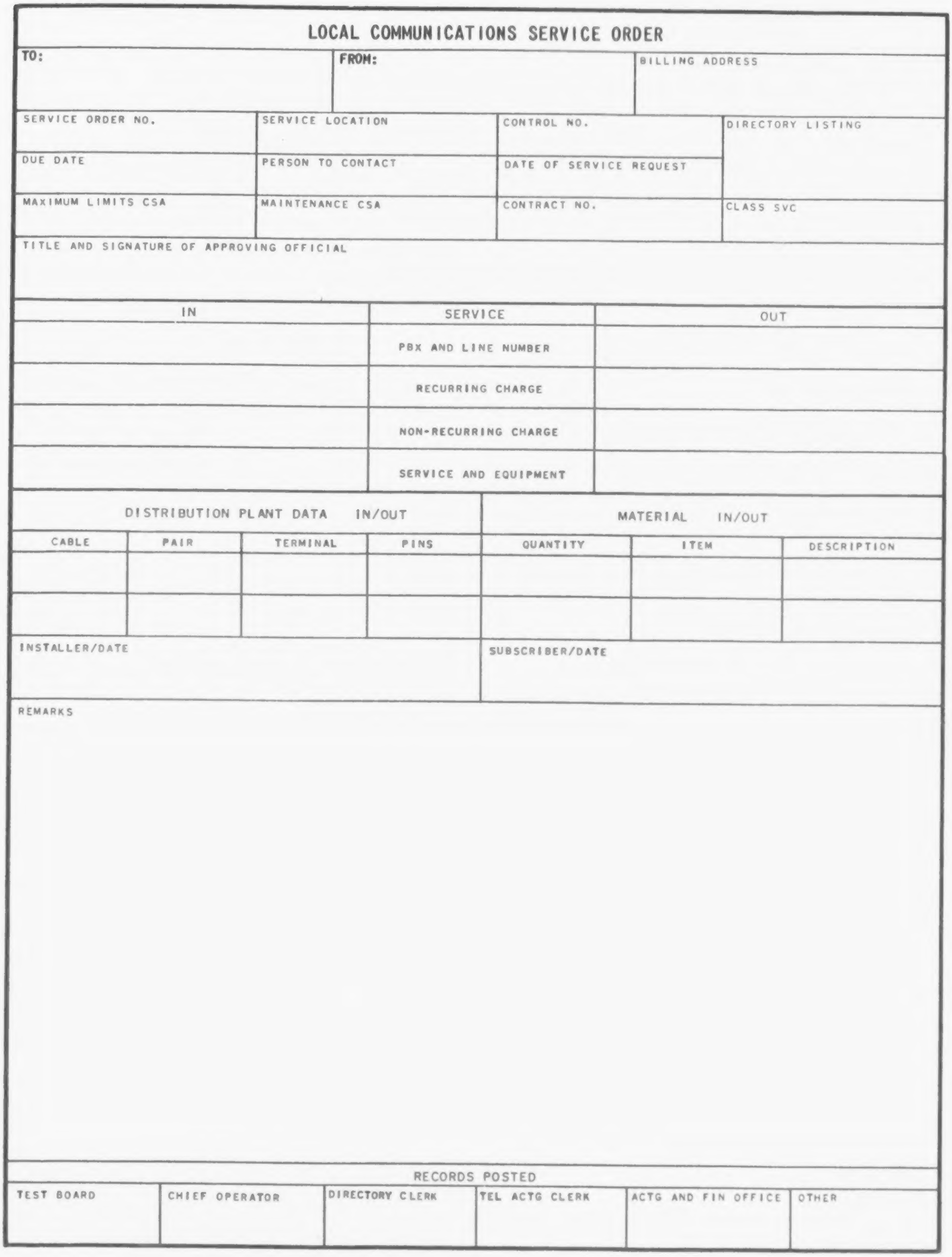
2. Identify the form on which to enter the nomenclature for a key system just installed in a requesting office.

3. What are the two types information included on telephone service records?

4. What type information should the block Material In/Out be considered?

706. Specify tasks in the maintenance of telephone records.

We noted in objective 699 that the base communications office keeps a copy of the voucher and the contractor's bill until the bill is paid. Hence, the records for which you may be responsible are often distributed to other offices as well as filed in your office. In other situations, the issuing agency



LOCAL COMMUNICATIONS SERVICE ORDER

TO:	FROM:	BILLING ADDRESS

SERVICE ORDER NO.	SERVICE LOCATION	CONTROL NO.	DIRECTORY LISTING
DUE DATE	PERSON TO CONTACT	DATE OF SERVICE REQUEST	
MAXIMUM LIMITS CSA	MAINTENANCE CSA	CONTRACT NO.	CLASS SVC

TITLE AND SIGNATURE OF APPROVING OFFICIAL

IN	SERVICE	OUT
	PBX AND LINE NUMBER	
	RECURRING CHARGE	
	NON-RECURRING CHARGE	
	SERVICE AND EQUIPMENT	

DISTRIBUTION PLANT DATA IN/OUT				MATERIAL IN/OUT		
CABLE	PAIR	TERMINAL	PINS	QUANTITY	ITEM	DESCRIPTION

INSTALLER/DATE	SUBSCRIBER/DATE

REMARKS

RECORDS POSTED					
TEST BOARD	CHIEF OPERATOR	DIRECTORY CLERK	TEL ACTG CLERK	ACTG AND FIN OFFICE	OTHER

Figure 7-1. Sample local communications service order.

may distribute a record to your office for filing and file a copy in their records. In another case, information from the distributed copy to the filing agency is entered on a permanent record and the information copy is then returned to the issuer or is destroyed. It should be seen from these statements that there are varying procedures used in the care of records. Use the distribution method as specified for the specific form.

Proper filing of records prevents their loss and provides easy access to the people using them. Usually you should have dividers to separate the records so that those which relate are in a group. Then, you mark each copy to be filed with an identifying group number and place it in the file in a specified sequence. To illustrate, the copy with the most recent date may be at the front of the group, or the most recent change to the equipment record may be in the front position. In the front of the file, you should place an index which should help the users to locate the filed copies. The index should identify the group and could briefly describe the information it gives. Set a maximum time limit for filing a new record or a new entry. If a record requires additional action, follow up to see that the action is accomplished as requested. If a record is to be removed for making a new entry on it, be sure that this action is annotated on a "charge out record." Use care with the record so that it isn't damaged while being handled. If a record is to be replaced, destroy it only after the replacement copy is in the file and in the manner specified by the controlling regulation.

To keep the file current and insure that the records are in their proper group, you should routinely inspect it. It is advisable that an inspection schedule be developed and an entry be made on it following completion of your inspection. The schedule could also include a space for entering the name of the inspector in the event that various people make the checks.

Some records require a meeting between representatives from the accounting and finance office and from the base communications office to agree on the record documentation. These meetings are to be scheduled for January, April, July, and October. The representatives compare more than one type form. Then following their agreement, they initial and date corrected copies. The corrected copies are then placed in the file.

Exercises (706):

1. Indicate three procedures required in the use of records.

2. What is the general practice for preparing a record for placement in a file?

3. How do you place a marked copy in the file?

4. What is the proper action when removing a record copy from a file?

5. What action should keep a file current and properly organized?

6. What is the schedule for reconciliation of telephone accounting records?

Glossary

Apparatus—Pieces of equipment used for a common function.

Audio-Frequency Amplifier—Device that increases the amplitude of frequencies that can be detected by the human ear (20 to 20,000 hertz).

Bimetallic Contacts—Contact springs formed of two dissimilar metals. The metals have different temperature expansion values. So when the temperature changes, the contact springs bend and separate their contacts.

Bridge—Electrical network used to provide a shunt-type circuit.

Cable Loop—Go-and-return conductors of a communication circuit; a complete circuit.

Cable Run—Path (position) of a cable that extends from one termination to a second termination.

Common—Connection that is attached to more than one unit, terminal, or wire.

Compatible Unit—Unit designed to work in harmony with associate units.

Crosstalk—Unwanted sound in a communication circuit—sound that results from neighboring communications or power circuits.

Dial Selective Intercommunications Circuit—Circuit that permits intercommunications stations to be selected and signaled by means of a dialed digit or digits.

EBM—Early break then make.

Electromechanical Interrupter—Magnetically operated device for opening and closing an electric circuit rapidly and periodically.

EMB—Early make then break.

GCA—Ground-controlled approach equipment that provides circuits used for providing accurate information for landing aircraft.

GCI—Ground-controlled interception method in which the intercepting weapon is guided to its target by instructions transmitted from the ground.

Impedance Switch—Switch that determines the opposite ratio between the intercommunications set and the interconnecting line.

Interlock—Arrangement that prohibits one action while enabling another or others.

Interoffice—Between stations in the same system.

Key Cable—Cable installed between bridging terminal and telephone.

Manual Intercom—Intercommunications system where control is by persons rather than by automatic devices.

MD—Manufacture discontinued.

Monitor—To check the operation and performance of a system by listening to the output sounds.

Multiple or Multiplicity of Circuit Connections—Two or more circuits connected in parallel.

Network—Two or more interrelated circuits.

Noise Suppression—Limit or reduce noise for a receiver circuit.

Noninductive Winding—A winding constructed so that the magnetic field of one turn cancels the magnetic field of an adjacent turn.

Opaque Material—Material that is neither transparent nor translucent.

Operations Van—Mobile unit where GCA controls and personnel are located that guide and regulate landed aircraft.

Package Unit—Combined units for providing common service to a requesting organization.

PBX (Private Branch Exchange)—Switchboard or automatic apparatus at a headquarters, which permits making outside calls from the local calls between subscribers.

Pigtail—Tightly twisted, bared conductors.

PMEB—Preliminary make with early break.

Pole Piece—Magnetic material formed to control distribution of the magnetic flux around associate devices.

Potentiometer—A three-terminal resistor with sliding contact which provides for variations in electrical circuit voltage.

Present Conference Circuit—Established circuit for permitting conversations between three or more stations simultaneously.

Rotary Stepping Switch—A bank and wiper switch where circuits are completed by the moving wipers, which move over the bank that is formed like the arc of a circle.

Running Cable—Cable installed between the key telephone units and the bridging terminal.

Short Circuit—Low-resistance connection between two points in a circuit. Also, can be called a shunt.

Station Diversification—Varied distribution of telephone stations.

Stop Pins—Devices on a relay that prevent the moving contact springs from going any further.

Subsequent—Succeeding; following later.

Supervision—Automatic indication of the operation or release of electrical circuits.

Suppression—Elimination of undesirable frequency or group of frequencies.

Terminal Punching—Metal stamping, tinned and designed to make a soldered connection with a wire.

Transient—Instantaneous surge of voltage or current which results from a circuit change.

Vibrator—Electromagnetic device used to change direct current into pulsating current.

Voice Frequencies—Audio range frequencies employed for transmission of speech. They usually range between 200 to 3500 hertz.

Wire-Line—Telephone communications system that uses wire conductors for the line circuit.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

600 – 1. It provides the customer flexibility in service selection.
600 – 2. Telephone and a junction or connecting block.
600 – 3. Power equipment and relay cabinet.
600 – 4. Central office access, intercom, hold, and exclusion.

601 – 1. Each unit provides specified features which enable flexibility in service.
601 – 2. Relay apparatus, circuits, and the required connections.
601 – 3. The manufacturer assembles and factory wires key telephone units into packages that provide the specific services requested by the user.

602 – 1. The subject single line unit operates when a key telephone PICKUP key is operated to connect the key station to a central office line.
602 – 2. Ringing and flashing lamp are two features provided by the subject KTU.
602 – 3. Intercom signaling and talking circuits.
602 – 4. DC for operating relays and the transmit circuit; AC for operating the supervision devices.

603 – 1. The line unit of the 1A1 system has wire-spring relays whereas the 1A2 system line unit shows a circuit card.
603 – 2. The 1A1 system relays are large, wire-spring type whereas the 1A2 system relays are miniature types installed on plug-in cards.
603 – 3. The 1A2 key system is smaller and therefore requires less space for an installation. Secondly, a defective unit is more easily removed and replaced with a reliable KSU.

604 – 1. The 6A key system provides a talk link arrangement that premits two private transmitting circuits for the customer.
604 – 2. CAMP-ON CONTROL.
604 – 3. 222A.
604 – 4. 224A.
604 – 5. 217A.

605 – 1. The PICKUP key connects the talking circuit key telephone to the central office line.
605 – 2. PICKUP keys 1 through 4 are connected in parallel.
605 – 3. The set is used with 4-wire service.
605 – 4. The 565LD has an exclusion key and a CUTOFF turn button which the 564HD doesn't have.
605 – 5. The 565 key telephone has five PICKUP keys.
605 – 6. HOLD pushbutton.

606 – 1. The Call Director has a greater number of pushbuttons for connection to communication lines and the construction is slightly different. Accordingly, the appearance of the sets differs greatly.
606 – 2. It is used by a receptionist in a large office or in a reception room common to many offices.

CHAPTER 2

607 – 1. Relay H, contact M4.
607 – 2. ST relay in 232B KTU.
607 – 3. Terminal 25.
607 – 4. Terminal 26.

608 – 1. Parallel.
608 – 2. Pulsing and off-normal contacts.
608 – 3. Metallic ring and grounded ring.

609 – 1. Unoperated contacts B4 (AH relay) and B9 (A relay).
609 – 2. Thermistor.
609 – 3. Contacts M4 of relay R, 4 and 5 of relay AH (230B KTU), and bimetallic contacts 1 and 2 near relay TO (232B KTU).
609 – 4. Option wiring.
609 – 5. TO relay.
609 – 6. Terminals 5 and 6.
609 – 7. LF.
609 – 8. Motor contacts 4 and 5.

610 – 1. The circuits to the flashing lamp source and to the audible signal source are opened. The telephone set lamp burns steadily, however.
610 – 2. A and AH (230B KTU) and TO (232B KTU).
610 – 3. R relay (230B KTU) and ST (232B KTU).
610 – 4. Terminals 3, 4, 13 and 14.
610 – 5. Ring.
610 – 6. A relay.
610 – 7. EBM8.
610 – 8. Contact B5 of relay AH in the 230B KTU.

611 – 1. PICKUP key, hookswitch, network, and terminal strip terminal.
611 – 2. 64 B1–75 terminal strip, running cable, 66 A1–25 terminal pins, 66 E3–25 connecting block, connector, plug, and mounting cord.
611 – 3. Relay A, contact EBM 12.

612 – 1. PICKUP key and relay A (230B KTU).
612 – 2. Relays H (230B KTU) and ST (232B KTU).
612 – 3. Relays AH and H (230B KTU) and TO and ST (232B KTU).
612 – 4. A lamp winks and the telephone transmission circuit is open to the 230B KTU.

613 – 1. No illuminated lamps on the key telephone.
613 – 2. No telephone calls will be incoming.
613 – 3. The RING circuit connection from terminals 8, 12, and 2.

614 – 1. 1B and 2B.
614 – 2. −26 volts.
614 – 3. 39B and 40B, 105 VAC.
614 – 4. Depress the INTERCOM pushbutton and lift the handset.
614 – 5. A and B.
614 – 6. B, C, and T.
614 – 7. Relays B and T are connected to the KS–16171 network for its timed release feature while the C relay has a second winding for providing the timed release.
614 – 8. 2, 3, 4, 5, 6, 7, 8, 9 and 0.
614 – 9. M6.
614 – 10. Rotary magnet A.
614 – 11. The C relay operates and makes contact M4 which connects ground to terminal U or relay T.
614 – 12. The first movement of the stepping switch presses a pawl that operates the switch.
614 – 13. Relays B and T are operated and relay C is released.
614 – 14. Dial the assigned digit again.

615 – 1. 12 and 13.
615 – 2. −24 VDC.
615 – 3. Q1 is operated and Q2 & Q3 are off.

616 – 1. C relay contacts 2.
616 – 2. Ground for CT charging circuit.
616 – 3. Q1 cuts off and Q2 & Q3 operate.
616 – 4. Q3.

617 – 1. Contacts 1.
617 – 2. a. Capacitor CT.
b. Diodes (CR4, CR5, CR6, CR7) and resistors R14, R15, R6, RT1 and RT2.

618 – 1. Relay A.
618 – 2. Resistor R6 and contacts 5 of relay C.
618 – 3. Terminals 1, 8, 6, and 10.

619 – 1. Relays L, B, and C.
619 – 2. Q2 and Q3.
619 – 3. Terminal 14.
619 – 4. Terminal 9.
619 – 5. 8, 9, and 10.

620 – 1. Contacts 3 relay A, contacts 6 relay C, terminals R and T, R1, contacts 3 relay B, and contacts 2 relay C.

621 – 1. Capacitor C5 plate terminal.
621 – 2. Contacts 6.

622 – 1. M6.
622 – 2. Punchings 12B, 27B and 29B.
622 – 3. LB.

623 – 1. First winding of relay C, operated contacts EMB of relay B, and released contacts B10 of relay A.
623 – 2. Relay A is released and relay B is operated; also, relay C operates simultaneously with the operation of the rotary magnet.
623 – 3. M4 of relay C.

624 – 1. Relay LTR is released.
624 – 2. Relay BC is released by a shunting action whereas relay BC1 releases because of an open circuit.
624 – 3. Punchings, 7A, 100, 39A, and 40A, and option AL.
624 – 4. 3B.
624 – 5. 4B, 14B, 24B and 34B.

625 – 1. 29B and 30B.
625 – 2. TB1 operates first, followed by the operation of TB2 at which time relay TB1 releases.
625 – 3. Punchings 3D on the 222A KTU and 3B on the 223A KTU.
625 – 4. Two LS, two LT and two L relays in the 223A KTUs and the TB2 and relay H in the 222 A KTU.

626 – 1. Flashing lamp and busy tone.
626 – 2. Relay BY in KTU 224A—contacts M4 and EM12 for busy tone—contacts M2 for lamp flashing circuit.
626 – 3. Dial a specific digit to operate units in a selector.
626 – 4. BY1 in the 224A KTU.
626 – 5. The primary link (relay TB1 circuit).

627 – 1. By dialing a specific number or depressing a particular pushbutton you seize the preset conference circuit.
627 – 2. Operated relays—B1 in 222A KTU and relays T and B in 207C KTU.
Released relays—Ro1 and PC1 in 217 KTU, C in 207C KTU, BY in 224A KTU, and LTR in 222A KTU.
627 – 3. Contacts B5 and B7 of relay PC1 of 217 KTU and contacts M10 of relay B1 in the 222A KTU.
627 – 4. Contacts 6 of relay LTR in the 222A KTU, contact M8 of relay PC1 in the 217 KTU, and contact M10 of relay B1 in the 222A KTU.
627 – 5. Relay LT—contacts BM 5 and relay LS—contacts EM2 and EMB8.

628 – 1. Relay B1.
628 – 2. Contacts M3—relay B1 in KTU 222A; contacts 5 and 7 and the thermal contacts of relay TD in the 217B KTU.
628 – 3. Lead CTO is at ground potential when relays TDA in KTU 217B and B1 in the 222A KTU are operated.

629 – 1. Dial a predetermined number or depress a specific pushbutton.
629 – 2. Two groups of six telephones and 12 telephones in one group.
629 – 3. Only one telephone is enabled to originate conferences.
629 – 4. 18.

CHAPTER 3

630 – 1. Is conduit in place, is adequate heating and air-conditioning provided, and is the construction such that dust should be negligible?
630 – 2. Is the space available so that the equipment will be accessible for maintenance and is there room for expansion?
630 – 3. Mark the equipment and its location and prepare the connection sheets.

631 – 1. Fast and reliable connections, and flexible service specifications.
631 – 2. The 1A1 package doesn't include a cabinet whereas the 1A2 package has this mounting support.
631 – 3. 207C—1A1 system and 401A for the 1A2 key system.
631 – 4. 227B.
631 – 5. 101G.
631 – 6. Since key telephones require different features, the cords to be ordered must have a varying number of pairs.

632 – 1. 19 and 20.
632 – 2. Red and brown.
632 – 3. 3C-4C (13C and 14C).
632 – 4. Punching 12.
632 – 5. 39B.
632 – 6. 14 and 26—230B, and 19 and 20—207C KTU.
632 – 7. 8.

633 – 1. Eye level—5 to 6 feet.
633 – 2. Close to or on a wall.
633 – 3. The room conditions for telephone equipment must be cool, dust and moisture free, well-lighted, and solid based.

634 – 1. Inventory the material.
634 – 2. A review of the customer's request and a key system's specifications should insure a reliable installation.
634 – 3. A reliable installation in a minimum of time and work procedures.
634 – 4. Safe work procedures.
634 – 5. A floor plan that shows markings for the equipment to be installed.

635 – 1. Keep a cable straight (both vertically and horizontally), and if two different size cables are installed conform the smaller cable's turn to that of the larger.
635 – 2. Adequate slack must be provided for probable future damage at the terminating point.
635 – 3. Turning the screw also improves the connection between the wire and terminal.
635 – 4. 1/8 inch.
635 – 5. Two.

636 – 1. Brown-white.
636 – 2. Solid white with an orange dash.
636 – 3. Solid slate with a red dash.
636 – 4. Running and Key.

637 – 1. Review installation cable placement specifications before terminating the cable.
637 – 2. Always place an iron in an out-of-traffic position and disconnect it when not using it.
637 – 3. Place an in-use reel at a safe distance from a stored reel and don't leave it unattended.
637 – 4. Constantly compare the cable length on the reel to the specifications, inspect closely for cable damage, and place the cable in its final position before cutting it.
637 – 5. Clamps and sewing.

638 – 1. Plug and receptacle and fan and forming methods.
638 – 2. Place the plug and receptacle side-by-side; then press until they mate properly.
638 – 3. Expose the conductors, fan them, and attach each conductor to the appropriate terminal.

639 – 1. Diagonal and longnose pliers.

639 – 2. Use the diagonal pliers to extend a cut plastic sheath for a short distance above the butt end of the cable.
639 – 3. Grasp the cord with longnose pliers, and pull the cord tightly until it has cut the insulation to the desired butt point.

640 – 1. Broken conductors and shorted pairs caused by moisture.
640 – 2. Plastic tape and ties.
640 – 3. Approximately 1 inch.

641 – 1. Holes.
641 – 2. With ties.
641 – 3. 30-type terminals are screw type and the 66-type terminals are clips.
641 – 4. Make the pair 1 conductors short and keep the longest conductors for the highest numbered pair in the group.
641 – 5. They are useful as spare wires.
641 – 6. The conductors for terminals 4, 5, 9, and 10.

642 – 1. Skinning a conductor.
642 – 2. 1/8 inch.
642 – 3. Fanning strip.
642 – 4. There is to be only one wire under each washer.
642 – 5. The conductor for each terminal must be terminated according to the prescribed color code arrangement.
642 – 6. Type-30 terminals require skinning and cleaning a wire and placing it under a screw terminal. The type 66 terminal is a clip and its spring-loaded lips cut through the insulation once you have forced the wire into position.

643 – 1. Key cable.
643 – 2. Each wire must be cut to proper length, skinned, and cleaned.
643 – 3. Some conductors from the cord extend to each connecting block.
643 – 4. Terminals 5, 7, and 8 of connecting block 4.
643 – 5. Each conductor is placed between two washers.
643 – 6. Fasten the wire link to the center screw.
643 – 7. The mounting cord has spade terminals whereas the key cable conductors must be skinned and cleaned.
643 – 8. Do not cross cord and cable conductors.

644 – 1. Pull the wire over the terminal notch and forcefully press it against the metal.
644 – 2. Scraping (tinning) of the wire.
644 – 3. Proper wires are attached to specified terminals, connections are solid, minimum shiner is showing, wiring and cables are neat and uniformly placed.

CHAPTER 4

645 – 1. A steady lighted lamp (calling telephone), a flashing lighted lamp (called telephone), dial tone, ringback tone, and accurate dial pulsing.
645 – 2. Winking lamp following depression of the HOLD key.
645 – 3. Normal talking and receiving volume and quality.
645 – 4. Each instrument must be able to operate independently from all other system stations.
645 – 5. All lamps light dimly, lamps flash incorrectly or don't flash.
645 – 6. Burned out components.
645 – 7. Improperly installed ground rod.

646 – 1. Dial tone and a lighted lamp (steady glow).
646 – 2. Second PICKUP lamp goes out and comes on again but with a wink or flash indication and the PICKUP key restores to normal.
646 – 3. A flashing lamp and a sounding bell or buzzer.
646 – 4. Lamp changes to a steady glow.
646 – 5. Steady lamp.
646 – 6. Steady lamp and one ring signal only.

647 – 1. For both systems the depressed HOLD key restores the operated PICKUP key and starts the lamp under the PICKUP key to winking.
647 – 2. With both systems, the operated EXCLUSION key must prevent the excluded stations from receiving dial tone, sidetone, incoming ring, etc.
647 – 3. In both cases, this quality is determined by talking to an assistant. You monitor for clarity and volume.

648 – 1. Two-talk link, camp-on, and preset conference features checks.
648 – 2. The dialed intercom number flashes the lamp and rings the bell at the selected station while the lamp for the remainder of the intercom stations glows steadily.
648 – 3. The selected and caller stations lamp remains lighted with a steady glow and all other station lamps go out.
648 – 4. Two calls (four participants) can be held at the same time without cross-talk or circuit interference.
648 – 5. Busy tone.
648 – 6. All called stations lamps flash and their ringers sound.
648 – 7. All lamps flash then each lamp changes to a steady glow following the lifting of the handset and the companion key operation.
648 – 8. Free movement (no drag or delay in the component's movement).

649 – 1. Transmission and signaling tests.
649 – 2. Fuzzy or no dial tone and dial clicking while dialing.
649 – 3. Scratching or sizzling.
649 – 4. Signaling out test.
649 – 5. Lamps and bell.

650 – 1. Lighted lamp.
650 – 2. Analysis of circuit diagrams, inspection of the equipment, and circuit testing.

651 – 1. Open circuit and short circuit.
651 – 2. An increase in current.
651 – 3. A decrease in current and increase in resistance.

652 – 1. Switch contacts, relays A and B in the selector circuit, and the lamp.
652 – 2. The lamp is defective. The other components had to be good in order for the call to be completed.
652 – 3. The lamp for that particular line PICKUP key is suspect.

653 – 1. Trouble analysis and operational check.
653 – 2. Isolate circuit components and test for circuit values.
653 – 3. Ohmmeter and buzzer type test unit.
653 – 4. No meter operation.
653 – 5. Central office equipment, incoming lines, and keyset connections and components.
653 – 6. Use a systematic process of elimination.

654 – 1. Analyze the trouble report, make an operational check of the equipment, and use a systematic checkout procedure to isolate and locate the fault.
654 – 2. A burnt out lamp is the problem if PICKUP key 3 for all other stations in the system operate normally. If all No. 3 lamps fail, suspect the contacts at relays R, or AH, or A.
654 – 3. The interrupter contacts for line 3 also serve line 4.
654 – 4. Blown fuses, relay contacts, and an open mounting cord conductor.
654 – 5. Testing periodically and using a well organized program.

655 – 1. The mechanical units—relays and switches.
655 – 2. Inspection and readjustment.
655 – 3. Current-flow test set.

656 – 1. Electrical and mechanical.
656 – 2. Test and readjust.
656 – 3. Spring gauging, spring tensioning, contact spacing, and contact alignment.
656 – 4. The relay operation won't move the springs.
656 – 5. Contacts must align within 1/3 of their base diameter.
656 – 6. Contact follow.
656 – 7. Twenty-two thousands of an inch.
656 – 8. Relay must operate with 15.1 milliamperes of current in the winding and must not operate with less than 10.2 milliamperes in the winding.

657 – 1. Relay and switch maintenance is most effective when it prevents equipment outages rather than clearing them.
657 – 2. Procedures consist of inspecting and doing an operational check. Testing and readjusting are done only as a last resort.
657 – 3. Test for electrical values and readjust the mechanical parts to permit the unit to meet the specifications.

658 - 1. Remove the defective equipment and replace it with a good equipment.
658 - 2. KTU, key station, and cable.

659 - 1. A wire wrap gun is used to terminate a wire on a solderless terminal.
659 - 2. Place the wire in the tool bit, insert the bit over the terminal, and pull the trigger. Then, let the tool back away slightly during the installation.
659 - 3. A solderless connection must be a quality metal-to-metal high pressure connection, be gastight, have mechanical stability, and must not be under great stress.
659 - 4. 1/16 inch.
659 - 5. Five.
659 - 6. Connections must be made on the same level, there must be some slack for the wire, and wire must not be wrapped on the terminal taper.
659 - 7. The wire must be wrapped in the same direction that the future wraps will be so that the latter connections will not unwrap the former.
659 - 8. Wraps must never overlap, there must be 1/64 inch space between each conductor at two adjacent terminals, and there must be 1/2 the wire diameter (or less) spacing between adjacent turns.

660 - 1. Short straps may be bare if there is no danger of a short-circuit.
660 - 2. Cross-connect the two common potential terminals by connecting the tinned ends of an insulated wire to each. The insulation area of the strap must bypass around the unrelated terminals.

661 - 1. Operate the equipment.
661 - 2. The trouble should be isolated to the faulty unit.
661 - 3. Visual inspection and test equipment point-to-point check.
661 - 4. First, think about your task (what you're going to do) and then do the procedures in a systematic manner.

CHAPTER 5

662 - 1. Press the HOLD pushbutton in line with and parallel to the fourth line PICKUP pushbutton and line busy lamp.
662 - 2. The OFF-WIRE-RADIO keys are near the face panel and at the rear of the controller's shelf.
662 - 3. The OFF position removes the connection of the controller's shelf controls to the wire and radio circuit.
662 - 4. The controller's position headset is open.
662 - 5. Radio communications.

663 - 1. Visual and audible.
663 - 2. Lamp.
663 - 3. Loudspeaker and chime.
663 - 4. Control tower.
663 - 5. White.
663 - 6. Red.

664 - 1. One-way voice circuit.
664 - 2. Operates in conjunction with the PAR switch to permit voice reception.
664 - 3. One-way voice circuit is prepared for transmission and a lamp for the equipment panel is illuminated.
664 - 4. The position acknowledgment lamps.
664 - 5. A darkened controller's panel.

665 - 1. Operations and power vans.
665 - 2. Equipment cabinet.
665 - 3. Visual signaling and radio telephone circuits.
665 - 4. Voice and GCI voice signaling circuits.
665 - 5. Station line.
665 - 6. J86731D-1.
665 - 7. Fuses.
665 - 8. J53009CW, J53009CY, J53009CB, J53009CU.

666 - 1. Operate the LINE, the OFF-WIRE-RADIO (to wire), and FLASH-RING keys and insert the headset into the associate jack.
666 - 2. A, SL, PL, C, and S.
666 - 3. WT2.
666 - 4. Flashing lamp and bell. The flashing lamp will be seen at the controller's console and the bell at the weather station.

667 - 1. A, C, PL.
667 - 2. Two H, the L, SL, and WT1.
667 - 3. Contacts EMB5 of relay SL.
667 - 4. CR1 and CR2.

668 - 1. Relays C, CB, RS and CT.
668 - 2. The top contacts illustrated on foldout 5.
668 - 3. TB1, WT and CT.
668 - 4. 3 and A of relay C, 5 and 6B of relay CT, and 1 and 2B of relay RS.
668 - 5. 1 and 3T of relay AB

669 - 1. With the station line, the H relay negative battery is connected to contacts 1 and 2 of the L relay, whereas the negative battery connection for the PBX line H relay is at contacts 1 and 2 of relay A.

670 - 1. Relay SL.
670 - 2. Relay H.
670 - 3. Relay WT1 releases, followed by the release of relays WT and SL. The released relay SL opens the operating circuit to relays A and C.

671 - 1. Ground connected to the winding of relay ST by the operated relay FL.
671 - 2. A wire in a cable that interconnects between the J53033N and J53033M relay units.
671 - 3. Relay A operates to complete the operating circuit of relay B. The operated relay B then opens the circuit to relay A, and the released A relay, in turn, restores the operated relay B.

672 - 1. Multiple cabling.
672 - 2. LP CONT key is turned OFF.
672 - 3. BO1 and FL.
672 - 4. FL, contacts 8 and BO1, contacts 10.
672 - 5. Press the GREEN pushbutton to connect ground to the operating circuit of relay AC (3).
672 - 6. A2, contacts EBM10 and BO2, contacts EBM11.

673 - 1. The tower operator depresses the RED pushbutton to connect ground potential to the operating circuit of relay AC (4) in the power van.
673 - 2. The A3 and BO3 relays operated, and relay BO3 in turn opened the negative battery connection for relay BO2, thereby shutting off the AMBER light.
673 - 3. Depress the GREEN pushbutton for a second time, thereby developing the shunt consisting of contact M1 for relay K3, contact EMB8 for relay BO3 and contact EBM2 for relay BR2.

674 - 1. Ground is connected to the winding of relay PT1 in the power van. Hence it operates to couple the console headsets to the voice circuit and light the controller's lamps.
674 - 2. Relay CH.
674 - 3. Terminals 41 and 31 of the terminal strip for the J53033B unit.
674 - 4. Terminals 33 and 43 for terminal strip A.

675 - 1. Contact 3B of relay WT2 and the RG contacts of the OFF key.
675 - 2. The RG contacts of the OFF key.

676 - 1. Operations van and control tower.
676 - 2. At the operations van inspect the switches, dials and potentiometer. At the control tower also inspect the switches and volume control (potentiometer).
676 - 3. Power van.
676 - 4. Power van and control tower.
676 - 5. Plug—corrosion, bend, and excessive wear.
Cords—Excessive wear and broken components.

677 - 1. Doing a performance test.
677 - 2. Performance.
677 - 3. Test identification, time required to complete the test, and proper symptoms.

677 – 4. When doing a service routine.
677 – 5. Personnel and materials required for doing the routine.

678 – 1. Bulb is open.
678 – 2. Perform check of all other lamps to insure that the common battery connection provided by the ON switch is good and check too all the power van relays for operation as each switch is operated because they are commonly grounded at the ON switch.
678 – 3. Relay A and its contacts EM9, relay K4 and its contacts, M12, relay B04 and its contacts A9, EMB11, and EBM12.

679 – 1. Electrical testing and mechanical adjusting.
679 – 2. Don't be aggressive when working around relays, touch relay contacts only as a last resort (during correction), and keep relays covered constantly.
679 – 3. Use a sawing movement to brush relay contacts carefully to remove dust, burnish a contact corroded excessively but only as the last action left to overcome its serious condition. Readjust a spring's tension to a tension higher than the test value, and clean pole pieces and armature with clean paper.
679 – 4. Place protective cap over each connector when it is to be left unattached temporarily and be sure that all cables are properly mated.

CHAPTER 6

680 – 1. Telephone sets, ringer-telephone, and loudspeaker.
680 – 2. Operations van.
680 – 3. Pushbutton, lamps, dial, and handset.
680 – 4. Visual supervision.
680 – 5. Audible supervision.

681 – 1. Printed circuit boards and line impedance matching (switch--resistance) panel.
681 – 2. Switchboard.
681 – 3. Process telephone calls and condition telephone lines.
681 – 4. Change AC to DC.
681 – 5. In the power van.

682 – 1. Common-base, common-emitter and common-collector.
682 – 2. Provides moderate amplification and the output signal is in phase with the input signal.
682 – 3. Provides excellent amplification, and the output signal is out of phase with the input signal.
682 – 4. Both have in-phase input and output signals, and both are seldom used as amplifiers.

683 – 1. E.
683 – 2. A (emitter-follower) and E.
683 – 3. Symbol A.
683 – 4. Circuit.

684 – 1. Symbol B.
684 – 2. The output signal from a NOR-gate is amplified and out of phase from the input signal.
684 – 3. Q1 operates and cuts off Q2; then Q2 operates and cuts off Q1.
684 – 4. A gate circuit requires one or more AC input signals and requires DC voltage for transistor bias.

685 – 1. A transistor type gate.
685 – 2. 9 and 10 for operated relay K3 and 5 and 6 for released relay K2.
685 – 3. A lamp should light and a buzzer or bell should operate.

686 – 1. Contacts 8 and 9 of released relay K2.
686 – 2. Q2, CR14, and CR15.
686 – 3. Q2 operates.

687 – 1. Electronic gate.
687 – 2. Electronic gate.
687 – 3. The transistor potentials change in conjunction with the voice variations. This in turn changes the potentials for the subsequent circuit devices.
687 – 4. Impedance matching network.

688 – 1. Line 10 has a three winding transformer whereas line 1 has two transformers.
688 – 2. Both relays have two sets of make contacts.
688 – 3. Relay K26 operates when ground potential is connected to the operating circuit, whereas relay K27 always has ground potential and requires a connection to the negative 24-volt potential for its operation.
688 – 4. Relay K29 operates from the ground at the line key, whereas relay K26 operates from a ground provided by the LOGIC HOLD unit which operates from the ground provided by the operated hold key.

689 – 1. K97, contacts 6 and 7 and 9 and 10; K100, contacts 12 and 13 and 15 and 16.
689 – 2. Terminals 13 and 15.
689 – 3. The ringer.

690 – 1. –4 volts.
690 – 2. The straight line signals near the center of the face.
690 – 3. Test points 4 and 6.

691 – 1. Electronic switch.
691 – 2. 3,300 ohms—fourth step and 820 ohms—step 6.
691 – 3. –3 decibels per 100 Hz maximum change.
692 – 1. –5.5 decibels.
692 – 2. Terminal board 1 terminal 15.

693 – 1. Talking to a second person by means of the handset.
693 – 2. Have a second station originate a call to the station being tested.

694 – 1. Transistor Q1 in the dimmer control unit.
694 – 2. Heat coil or either logic boards RING OUT or OR.

695 – 1. Servicing and repair.
695 – 2. Replacement.
695 – 3. Workcards.
695 – 4. Technical order.
695 – 5. Status board.

CHAPTER 7

696 – 1. Dial, AUTOVON, and switchboard access.
696 – 2. Security police and fire department lines.
696 – 3. Key system installation.

697 – 1. Requested modifications and proposed extensions.
697 – 2. Research current equipment catalogs for costs and consult with users for any proposed changes or expansion.
697 – 3. Present telephone traffic, telephone service requirements, and available and required facilities.
697 – 4. Inventory of present system and compare costs of Government and contractor systems.

698 – 1. Service required.
698 – 2. Monthly charges (rate structure).
698 – 3. Technical accuracy and reasonable rates.

699 – 1. Control all Air Force calls and process telephone bills.
699 – 2. Verify calls, inventory records, investigate suspicious calls, and discipline guilty callers.
699 – 3. To determine if too much equipment is being leased.
699 – 4. Study the bills for accuracy and compare figures with established rates.
699 – 5. Local service charges, long distance callers and charges, and errors and omissions.
699 – 6. Confer with contractor and make agreement on questionable charges and prepare standard voucher.

700 – 1. Switchboard and coinbox telephone.
700 – 2. Red Cross and commissary.

701 – 1. Air Force AUTOVON grade-of-service policy.
701 – 2. Responsiblity assignment policy.
701 – 3. Only authorized poeple will have access to AUTOVON, and a semiannual traffic study is required.

702 – 1. Engineering personnel consultation and project accomplishment scheduling.
702 – 2. Supervisors, fellow workers, and customers.
702 – 3. Seek advice from leaders and associates, work accurately and do your fair share, show knowledge of the equipment and service when speaking to customers, and do it in a civil manner.

703 – 1. The telephone equipment survey determines the quality of the equipments performance and should indicate where potential problems may be.
703 – 2. Technical performance of the equipment and the quality of service by the maintenance people.

704 – 1. Government-owned and leased telephone equipment.
704 – 2. One year.
704 – 3. It is to be done in conjunction with technical or regular maintenance inspections and is to be recorded on specified forms.

705 – 1. Service order or work order.
705 – 2. Line or equipment record.
705 – 3. Technical and managerial.
705 – 4. Managerial—yet some people may consider it technical, too.

706 – 1. Preparation, distribution, and filing.
706 – 2. Mark it with a group identification number.
706 – 3. In a specified sequence.
706 – 4. Replace it with a "charge out record."
706 – 5. Routine inspection.
706 – 6. Quarterly.

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36254 04 S01 8102

SUPPLEMENTARY MATERIAL

CDC 36254

TELEPHONE EQUIPMENT INSTALLATION AND REPAIR SPECIALIST

(AFSC 36254)

Volume 4

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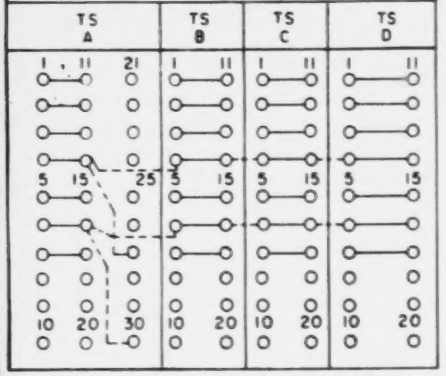
WARNING FOR CO OR PBX LINES		OPTION
METALLIC RINGING (FURNISHED)		Z
GROUNDED RINGING		Y
INTERRUPTED AUDIBLE SIG (FURNISHED)		X
STEADY AUDIBLE SIGNAL		W
LAMP MAX	MAX 40 LAMPS (FURNISHED)	S
	MAX 60 LAMPS	R

FACTORY STRAPPING OF TERMINAL STRIPS FOR THE 230A KEY TEL UNIT

DOTTED LINE - INTERNAL STRAPPING
SOLID LINE - SURFACE STRAPPING


TS A
TS B
TS C
TS D
1
11
21
5
15
25
10
20
30

NOTE 1 FOR THE 230A or B KTU. THE FOLLOWING APPLIES FOR PUNCHINGS 1 THROUGH 20

LINE 1 TERMINATES ON TERMINAL STRIP A
LINE 2 TERMINATES ON TERMINAL STRIP B
LINE 3 TERMINATES ON TERMINAL STRIP C
LINE 4 TERMINATES ON TERMINAL STRIP D
BATTERY AND GROUND TERMINATED ON TERMINAL STRIP A AND STRAPPED INTERNALLY

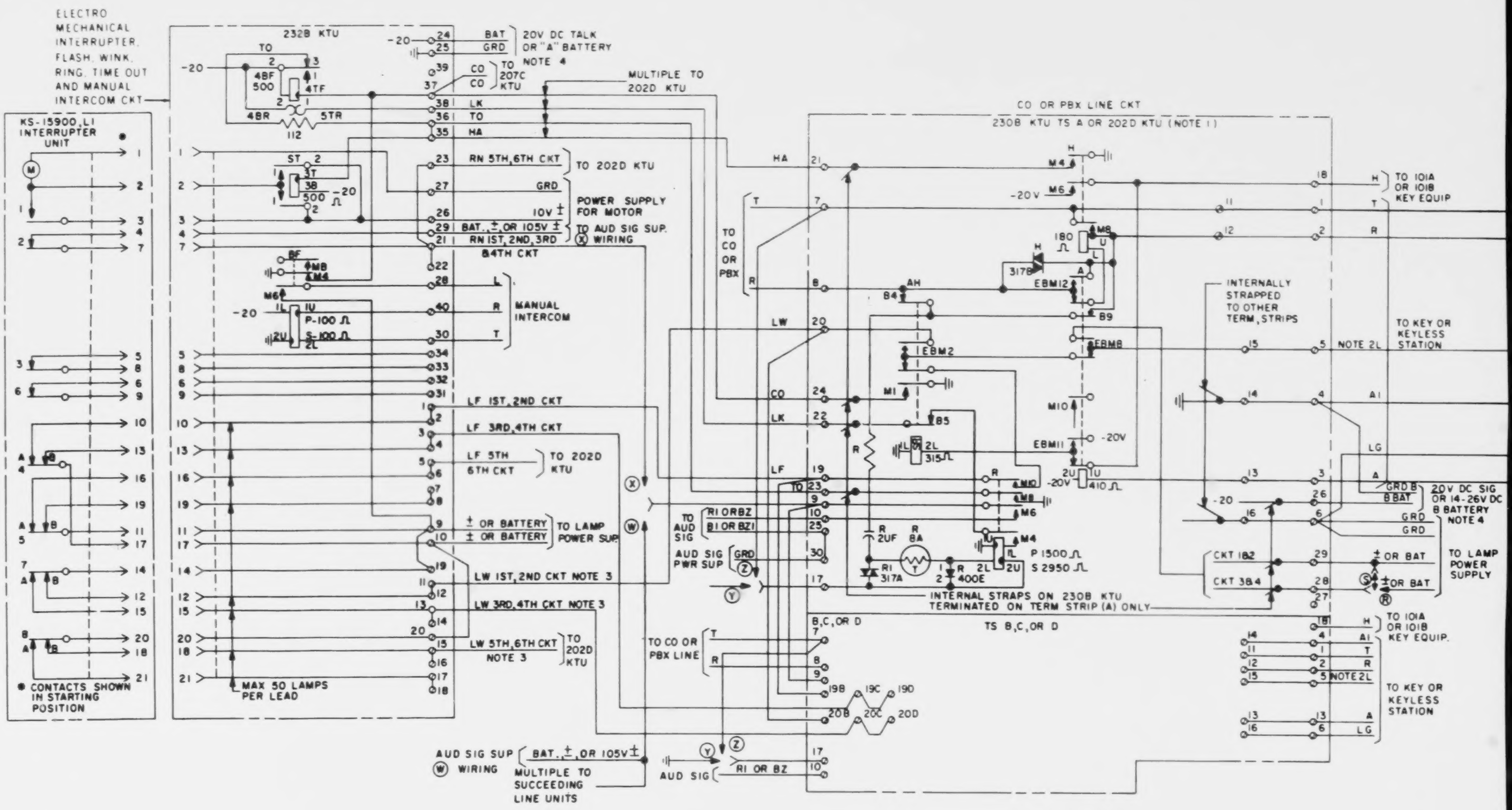
NOTE 2 MAXIMUM 20 LAMPS PER L LEAD

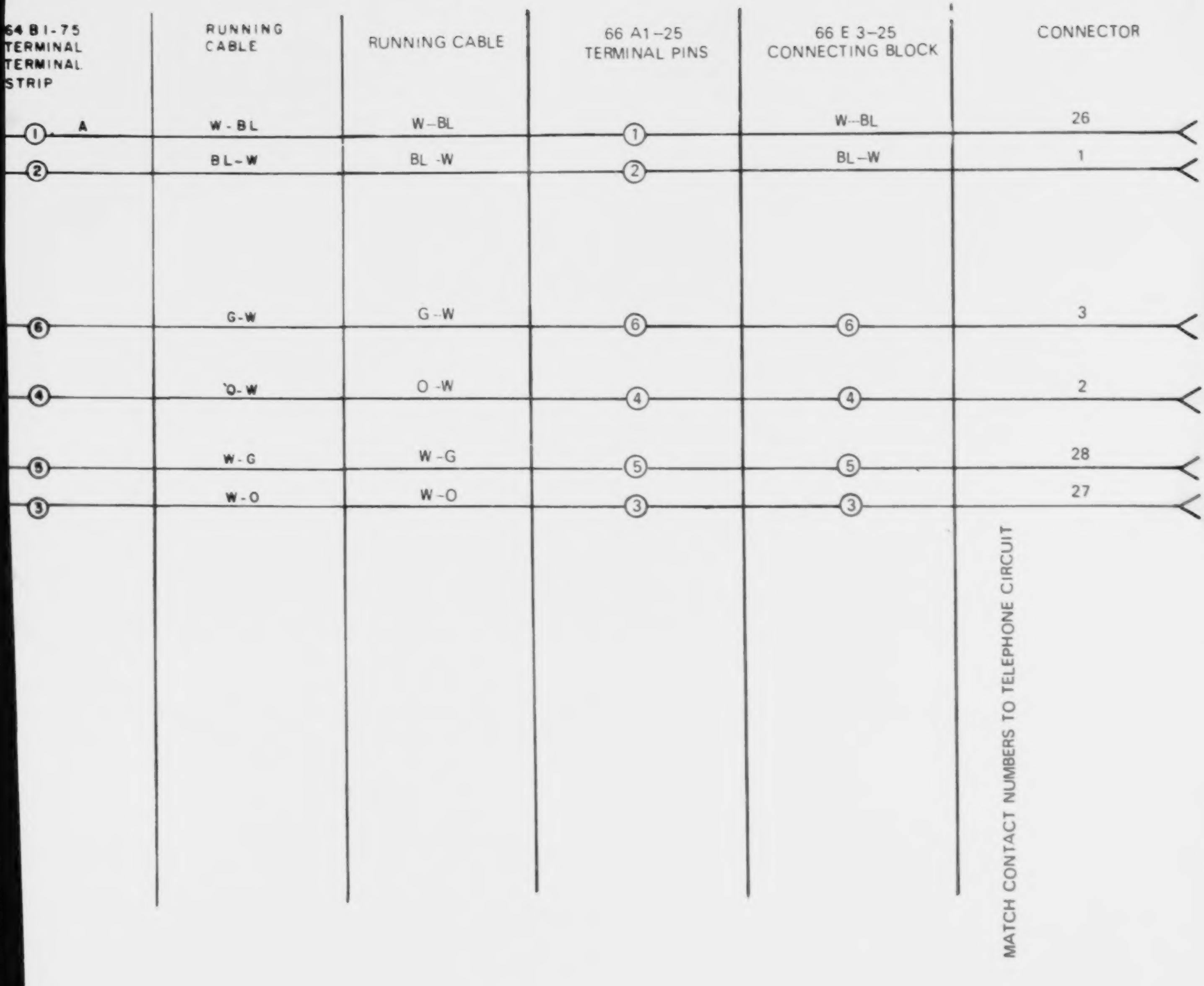
NOTE 3 WHEN STEADY HOLD LAMP IS REQUIRED INSTEAD OF LAMP WINK. PROVIDE STRAPS AS FOLLOWS

202C & 2020 KTU - TERM 20 AND 29
230A KTU - TERM 20A. B. C. D. AND 29A
230B KTU - TERM 20A. B. AND 29A
TERM 20C. D. AND 28A

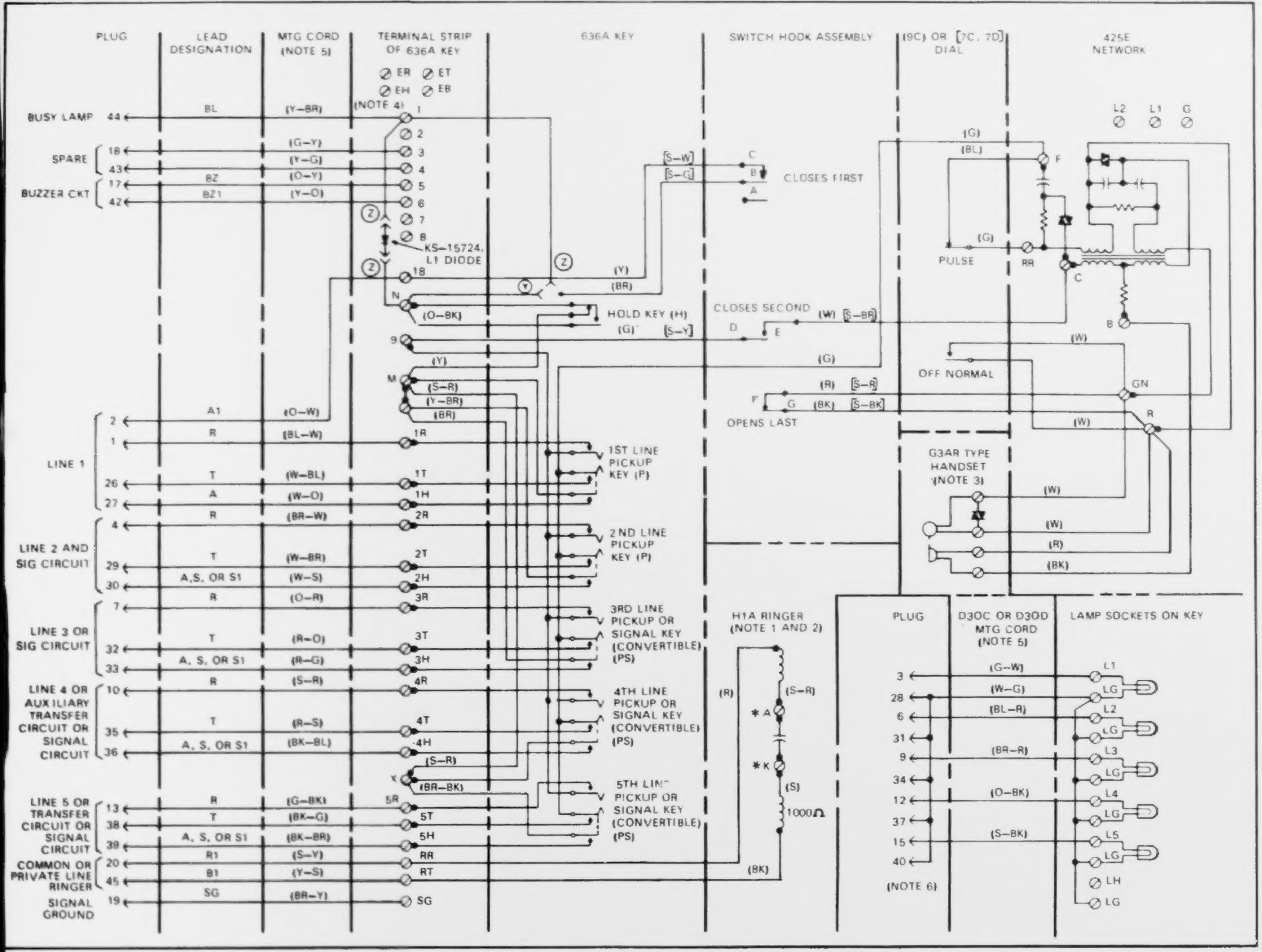
CAUTION: IF PACKAGE INTERRUPTER IS USED TO FURNISH LAMP WINK FOR OTHER SYSTEMS DISCONNECT AND TAPE LW LEADS AT TERMINAL 20 OF EACH LINE CIRCUIT NOT USING THE WINK FEATURE.

NOTE 4 A AND B GROUNDS MUST BE CONNECTED TOGETHER AT POWER SUPPLY


ELECTRO MECHANICAL INTERRUPTER, FLASH, WINK, RING, TIME OUT AND MANUAL INTERCOM CKT
KS-15900,L1 INTERRUPTER UNIT
M
CONTACTS SHOWN IN STARTING POSITION
232B KTU
TO
-20
4BF 500
4TF
4BR
5TR
112
ST
3T
3B 500
P-100
S-100
1U
1L
2U
2L
M6
M8
BF
EM4
BAT
GRD
20V DC TALK OR "A" BATTERY NOTE 4
CO
TO 207C KTU
LK
TO
HA
MULTIPLE TO 202D KTU
RN 5TH,6TH CKT
TO 202D KTU
10V ±
POWER SUPPLY FOR MOTOR
BAT., ±, OR 105V ±
TO AUD SIG SUP. WIRING
RN 1ST, 2ND, 3RD & 4TH CKT
L
R
T
MANUAL INTERCOM
LF 1ST, 2ND CKT
LF 3RD, 4TH CKT
LF 5TH 6TH CKT
± OR BATTERY
TO LAMP POWER SUP.
LW 1ST, 2ND CKT NOTE 3
LW 3RD, 4TH CKT NOTE 3
LW 5TH, 6TH CKT NOTE 3
TO 202D KTU
MAX 50 LAMPS PER LEAD
AUD SIG SUP WIRING
MULTIPLE TO SUCCEEDING LINE UNITS
AUD SIG
RI OR BZ
CO OR PBX LINE CKT
230B KTU TS A OR 202D KTU (NOTE 1)
TO CO OR PBX
TO AUD SIG
RI OR BZ
BI OR BZI
AUD SIG PWR SUP
GRD
LW
LF
H
M4
-20V
M6
M8
U
180
3178
EBM12
AH
B4
B9
EBM8
EBM2
M1
M10
B5
2L 315
EBM11
-20V
2U 410
R
2UF
8A
R1 317A
400E
P 1500
S 2950
INTERNAL STRAPS ON 230B KTU TERMINATED ON TERM STRIP (A) ONLY
INTERNALLY STRAPPED TO OTHER TERM. STRIPS
TO 101A OR 101B KEY EQUIP
TO KEY OR KEYLESS STATION
NOTE 2L
A1
LG
A
GRD B
B BAT
20V DC SIG OR 14-26V DC B BATTERY NOTE 4
GRD
CKT 1&2
CKT 3&4
± OR BAT
TO LAMP POWER SUPPLY
TS B,C,OR D
B,C,OR D
TO CO OR PBX LINE
19B
19C
19D
20B
20C
20D
X
W
Y
Z
S


64 B1-75 TERMINAL TERMINAL STRIP
RUNNING CABLE
RUNNING CABLE
66 A1-25 TERMINAL PINS
66 E 3-25 CONNECTING BLOCK
CONNECTOR
①
A
W-BL
W-BL
①
W-BL
26
②
BL-W
BL-W
②
BL-W
1
⑥
G-W
G-W
⑥
⑥
3
④
O-W
O-W
④
④
2
⑤
W-G
W-G
⑤
⑤
28
③
W-O
W-O
③
③
27
MATCH CONTACT NUMBERS TO TELEPHONE CIRCUIT

8E 646 564 HWL TYPE TEL SETS ISSUE 2


PLUG
LEAD DESIGNATION
MTG CORD (NOTE 5)
TERMINAL STRIP OF 636A KEY
636A KEY
SWITCH HOOK ASSEMBLY
(9C) OR [7C, 7D] DIAL
425E NETWORK
ER
ET
EH
EB
(NOTE 4)
BUSY LAMP 44
BL
(Y–BR)
SPARE
18
43
(G–Y)
(Y–G)
BUZZER CKT
17
42
BZ
BZ1
(O–Y)
(Y–O)
KS-15724, L1 DIODE
CLOSES FIRST
CLOSES SECOND
OPENS LAST
HOLD KEY (H)
OFF NORMAL
PULSE
RR
L2
L1
G
F
C
B
GN
R
[S–W]
[S–G]
[S–BR]
[S–Y]
[S–R]
[S–BK]
(O–BK)
(S–R)
(Y–BR)
(BR)
LINE 1
2
1
26
27
A1
R
T
A
(O–W)
(BL–W)
(W–BL)
(W–O)
1R
1T
1H
1ST LINE PICKUP KEY (P)
LINE 2 AND SIG CIRCUIT
4
29
30
A, S, OR S1
(BR–W)
(W–BR)
(W–S)
2R
2T
2H
2ND LINE PICKUP KEY (P)
LINE 3 OR SIG CIRCUIT
7
32
33
(O–R)
(R–O)
(R–G)
3R
3T
3H
3RD LINE PICKUP OR SIGNAL KEY (CONVERTIBLE) (PS)
LINE 4 OR AUXILIARY TRANSFER CIRCUIT OR SIGNAL CIRCUIT
10
35
36
(S–R)
(R–S)
(BK–BL)
4R
4T
4H
4TH LINE PICKUP OR SIGNAL KEY (CONVERTIBLE) (PS)
(BR–BK)
LINE 5 OR TRANSFER CIRCUIT OR SIGNAL CIRCUIT
13
38
39
(G–BK)
(BK–G)
(BK–BR)
5R
5T
5H
5TH LINE PICKUP OR SIGNAL KEY (CONVERTIBLE) (PS)
COMMON OR PRIVATE LINE RINGER
20
45
R1
B1
(S–Y)
(Y–S)
RR
RT
SIGNAL GROUND 19
SG
(BR–Y)
SG
H1A RINGER (NOTE 1 AND 2)
(R)
(S–R)
*A
*K
(S)
1000Ω
(BK)
G3AR TYPE HANDSET (NOTE 3)
(W)
(R)
(BK)
PLUG
D3OC OR D3OD MTG CORD (NOTE 5)
LAMP SOCKETS ON KEY
3
28
6
31
9
34
12
37
15
40
(NOTE 6)
(G–W)
(W–G)
(BL–R)
(BR–R)
(O–BK)
(S–BK)
L1
LG
L2
L3
L4
L5
LH

NOTES

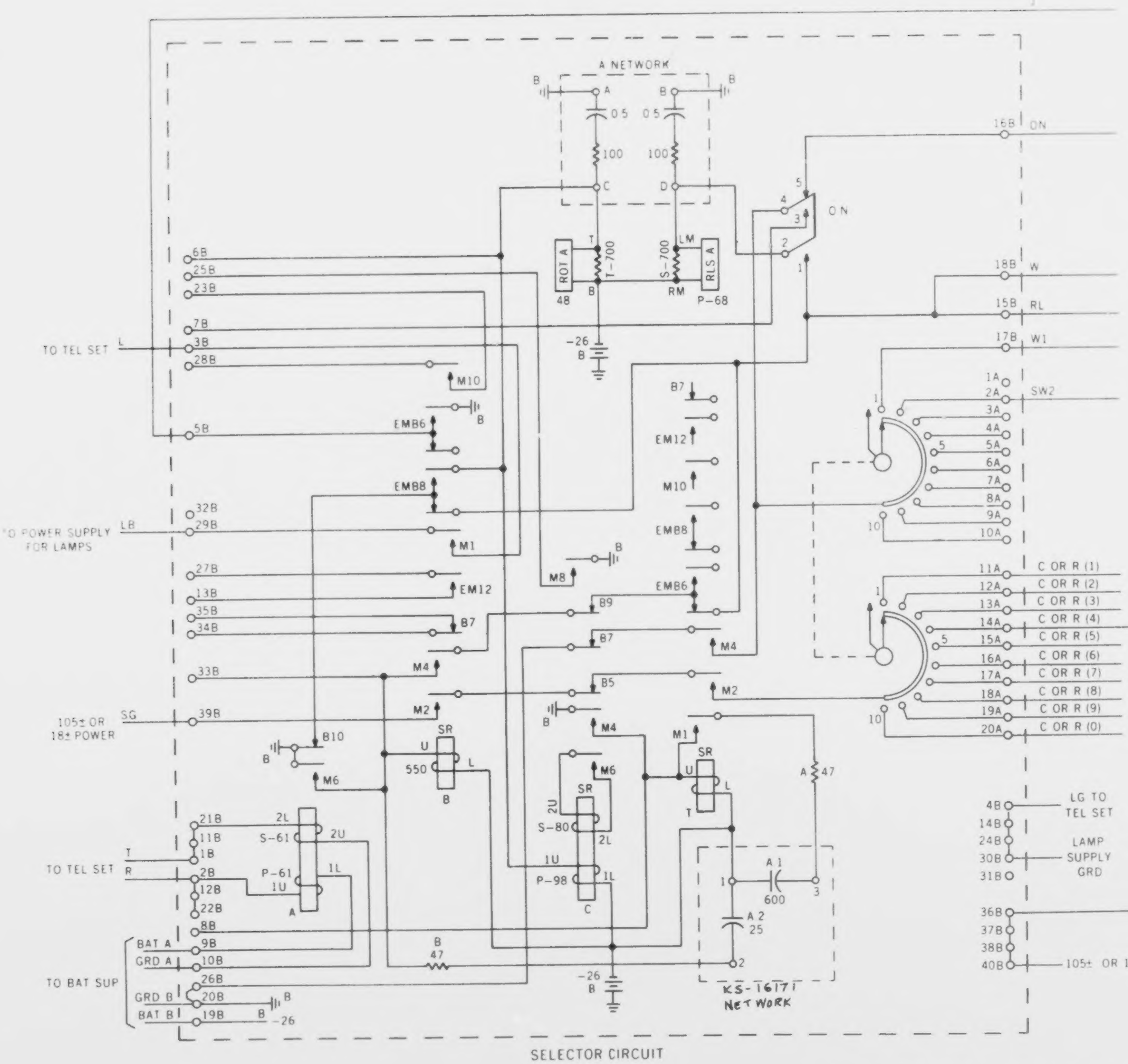
1. CONNECT RINGER WITHOUT CAPACITOR AS COMMON PRIVATE, OR INTERCOMMUNICATING LINE SIGNAL EXCEPT WHERE LOCAL INSTRUCTIONS DIRECT OTHERWISE RINGERS MUST BE WIRED WITH CAPACITOR IN CIRCUIT WHEN COMMON AUDIBLE SIGNAL POWER FAILURE FEATURE IS PROVIDED
2. RINGER LEADS ARE FACTORY WIRED, RED TO RR TERMINAL, BLACK TO RT TERMINAL
3. THE HANDSET MAY BE REPLACED BY ONE CONTAINING AN AMPLIFIER SUCH AS THE G6 TYPE (IMPAIRED HEARING) OR THE G7 TYPE (IMPAIRED SPEECH)
4. BL LEAD CONNECTED TO NETWORK L2 PUNCHING IN LATER MODEL TELEPHONE SETS
5. D3OC AND D3OD CORDS ARE USED WITH 564HK AND 564HL TELEPHONE SETS RESPECTIVELY
6. STRAP BETWEEN TERMINALS 28, 31, 34,37, AND 40 IS PROVIDED ON D3OD CORD ONLY

* TERMINALS ON NETWORK
( ) INDICATES CURRENT MANUFACTURE CODE
[ ] INDICATES MD CODE

OPTIONS

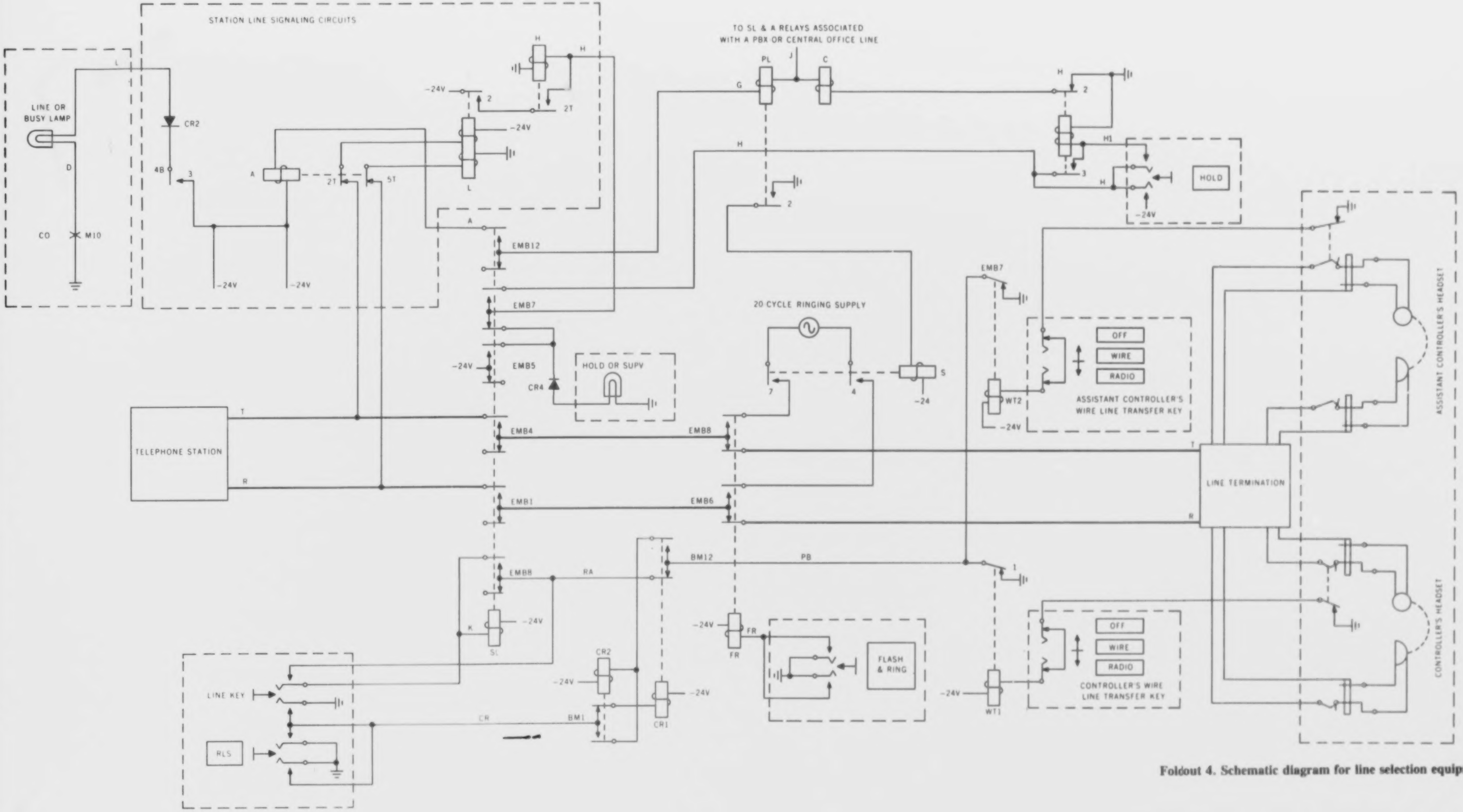
Ⓜ RINGER CKT
Ⓝ BUZZER CKT
Ⓩ WITH STATION BUSY LAMP
Ⓨ WITHOUT STATION BUSY LAMP

Foldout 1. 1A1 key system interconnections (schematic diagram).

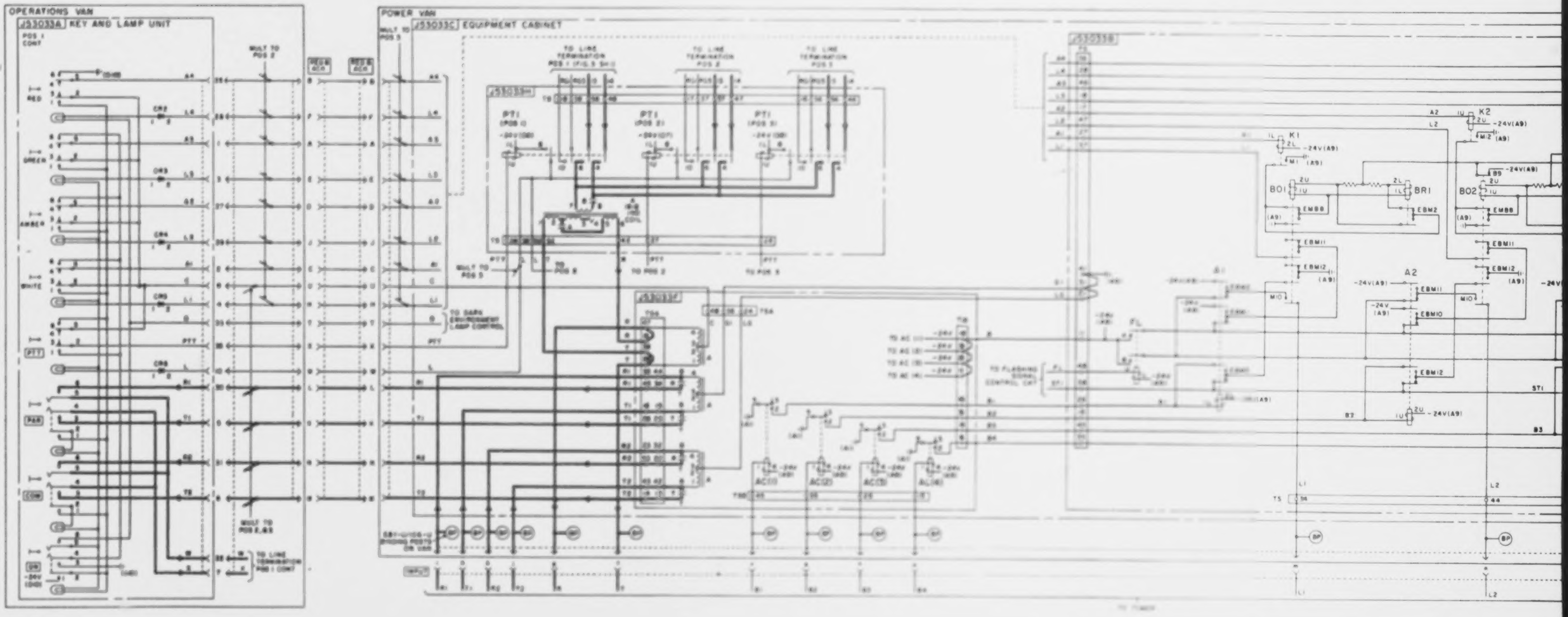

A NETWORK
B
A
B
0.5
0.5
100
100
C
D
ROT A
48
T
T-700
B
LM
S-700
RM
RLS A
P-68
-26
B
5
4
3
2
1
ON
16B
ON
18B
W
15B
RL
17B
W1
TO TEL SET
L
6B
25B
23B
7B
3B
28B
M10
B
5B
EMB6
EMB8
32B
TO POWER SUPPLY FOR LAMPS
LB
29B
M1
B7
EM12
M10
EMB8
EMB6
M8
27B
13B
35B
34B
EM12
B7
B9
33B
M4
M4
B5
M2
M2
105± OR 18± POWER
SG
39B
M2
B10
M4
M1
SR
U
550
L
B
M6
M6
SR
2U
S-80
2L
1U
P-98
1L
C
SR
U
L
T
A 47
1A
2A
SW2
3A
4A
5A
6A
7A
8A
9A
10A
11A
C OR R (1)
12A
C OR R (2)
13A
C OR R (3)
14A
C OR R (4)
15A
C OR R (5)
16A
C OR R (6)
17A
C OR R (7)
18A
C OR R (8)
19A
C OR R (9)
20A
C OR R (0)
1
5
10
21B
11B
1B
2L
S-61
2U
TO TEL SET
T
R
2B
12B
22B
P-61
1U
1L
A
8B
TO BAT SUP
BAT A
9B
GRD A
10B
26B
GRD B
20B
BAT B
19B
B
-26
B
47
-26
B
A 1
600
1
3
A 2
25
2
KS-16171 NETWORK
4B
LG TO TEL SET
14B
24B
30B
LAMP SUPPLY GRD
31B
BELL AT STA 4
36B
37B
38B
40B
105± OR 18± GRD
SELECTOR CIRCUIT

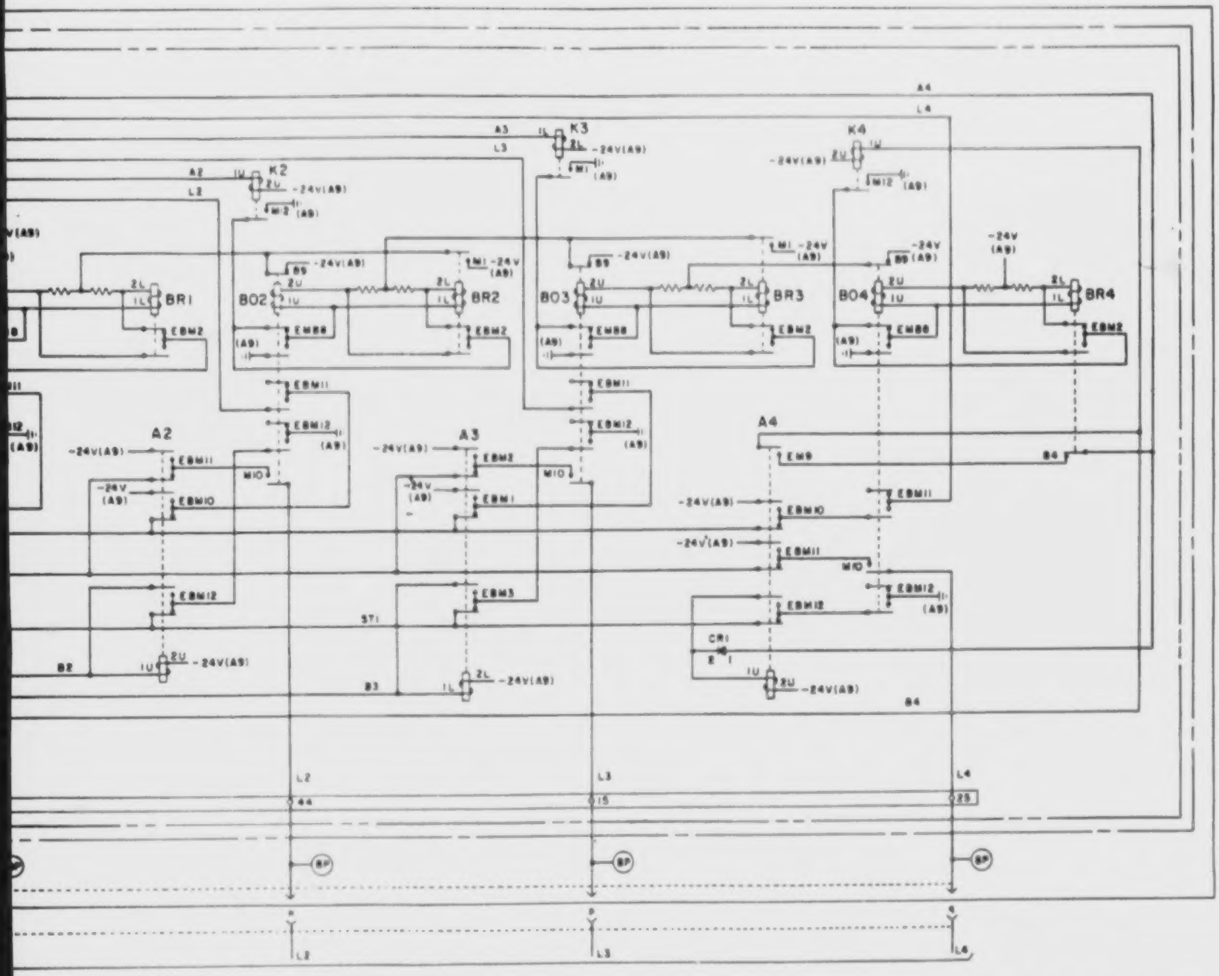
Foldout 2. Schematic diagram of key system selector circuit.

]

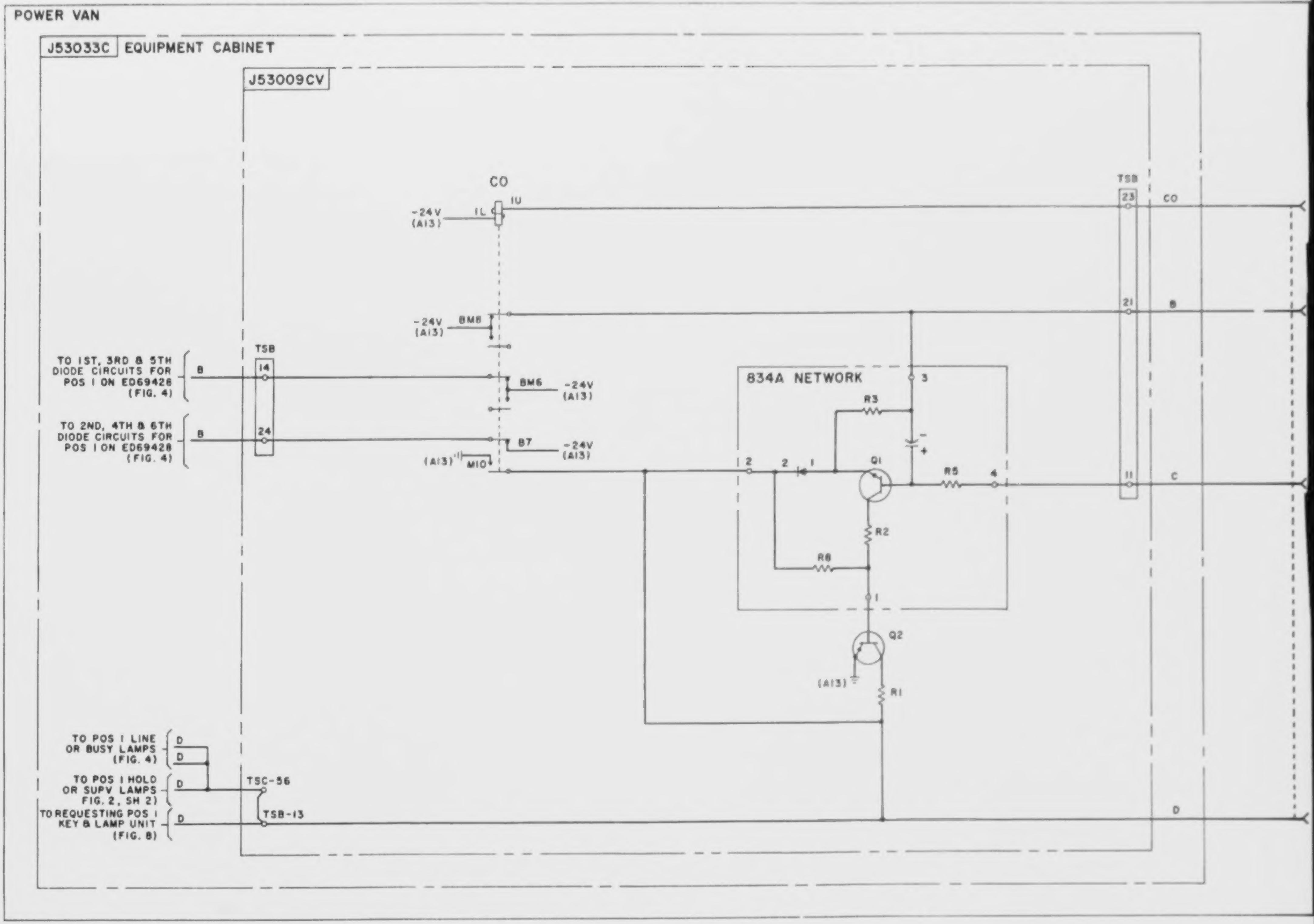

STATION LINE SIGNALING CIRCUITS
LINE OR BUSY LAMP
L
D
CO
M10
CR2
4B
3
-24V
-24V
A
2T
5T
L
H
H
-24V
2
2T
-24V
A
EMB12
EMB7
-24V
EMB5
CR4
HOLD OR SUPV
TELEPHONE STATION
T
R
EMB4
EMB1
EMB8
RA
K
SL
-24V
LINE KEY
RLS
CR
BM1
CR2
-24V
CR1
-24V
TO SL & A RELAYS ASSOCIATED WITH A PBX OR CENTRAL OFFICE LINE
PL
J
C
G
H
2
20 CYCLE RINGING SUPPLY
7
4
S
-24
EMB8
EMB6
BM12
PB
-24V
FR
FR
FR
FLASH & RING
H
2
H1
3
H
HOLD
-24V
EMB7
OFF
WIRE
RADIO
WT2
-24V
ASSISTANT CONTROLLER'S WIRE LINE TRANSFER KEY
1
-24V
WT1
OFF
WIRE
RADIO
CONTROLLER'S WIRE LINE TRANSFER KEY
T
LINE TERMINATION
R
ASSISTANT CONTROLLER'S HEADSET
CONTROLLER'S HEADSET

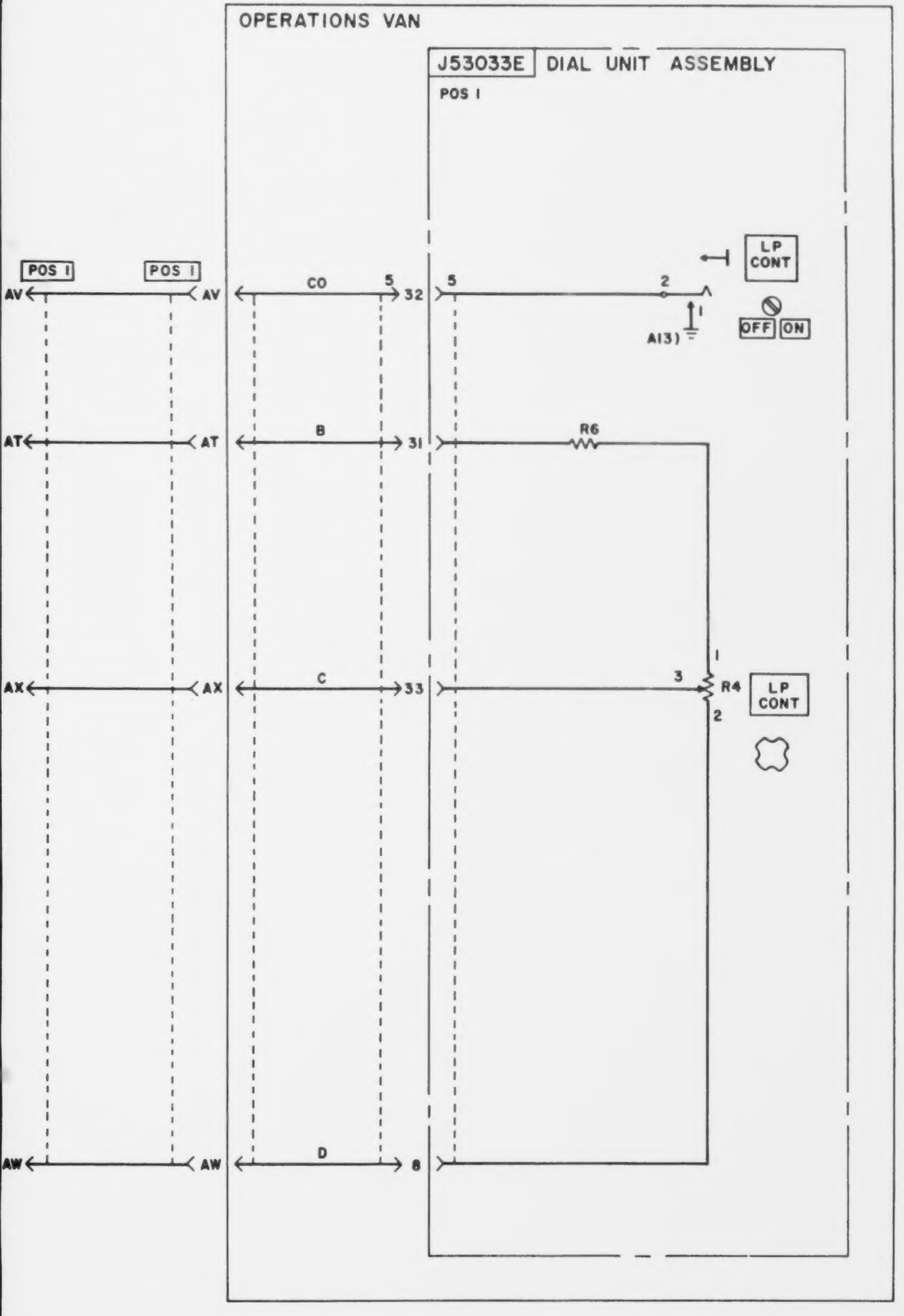
Foldout 4. Schematic diagram for line selection equipment.


OPERATIONS VAN
J53033A KEY AND LAMP UNIT
POS 1 CONT
MULT TO POS 2
RED
GREEN
AMBER
WHITE
PTT
PAR
COM
POWER VAN
MULT TO POS 3
J53033C EQUIPMENT CABINET
TO LINE TERMINATION
PT1
J53033F
J53033B
TO FLASHING SIGNAL CONTROL CKT
AC(1)
AC(2)
AC(3)
AL(4)
K1
K2
BO1
BR1
BO2
A2
EBM8
EBM11
EBM12
EBM10
-24V(A9)
(A9)
L1
L2
ST1
B2
B3
TS
BP

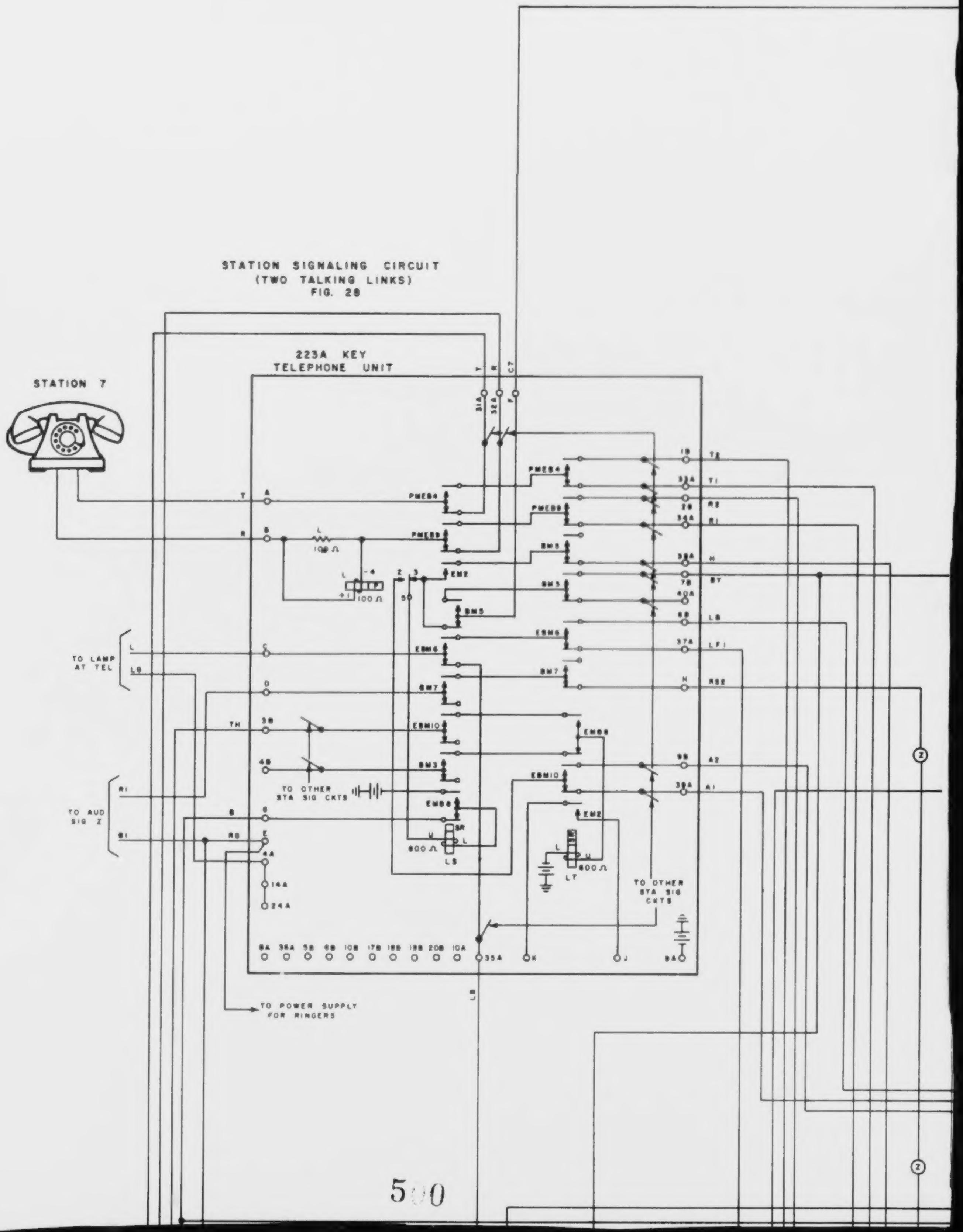

A4
L4
A3
L3
K3
-24V(A9)
M1
K4
M12
A2
L2
K2
M12
B9
BR1
BR2
BR3
BR4
BO2
BO3
BO4
EBM2
EMB8
EBM11
EBM12
EBM10
EBM1
EBM3
EM9
A2
A3
A4
M10
ST1
CR1
B2
B3
B4
-24V(A9)
(A9)
2L
1L
2U
1U
L2
L3
L4
44
15
25
BP

Foldout 6. Schematic diagram for request and acknowledgment equipment.

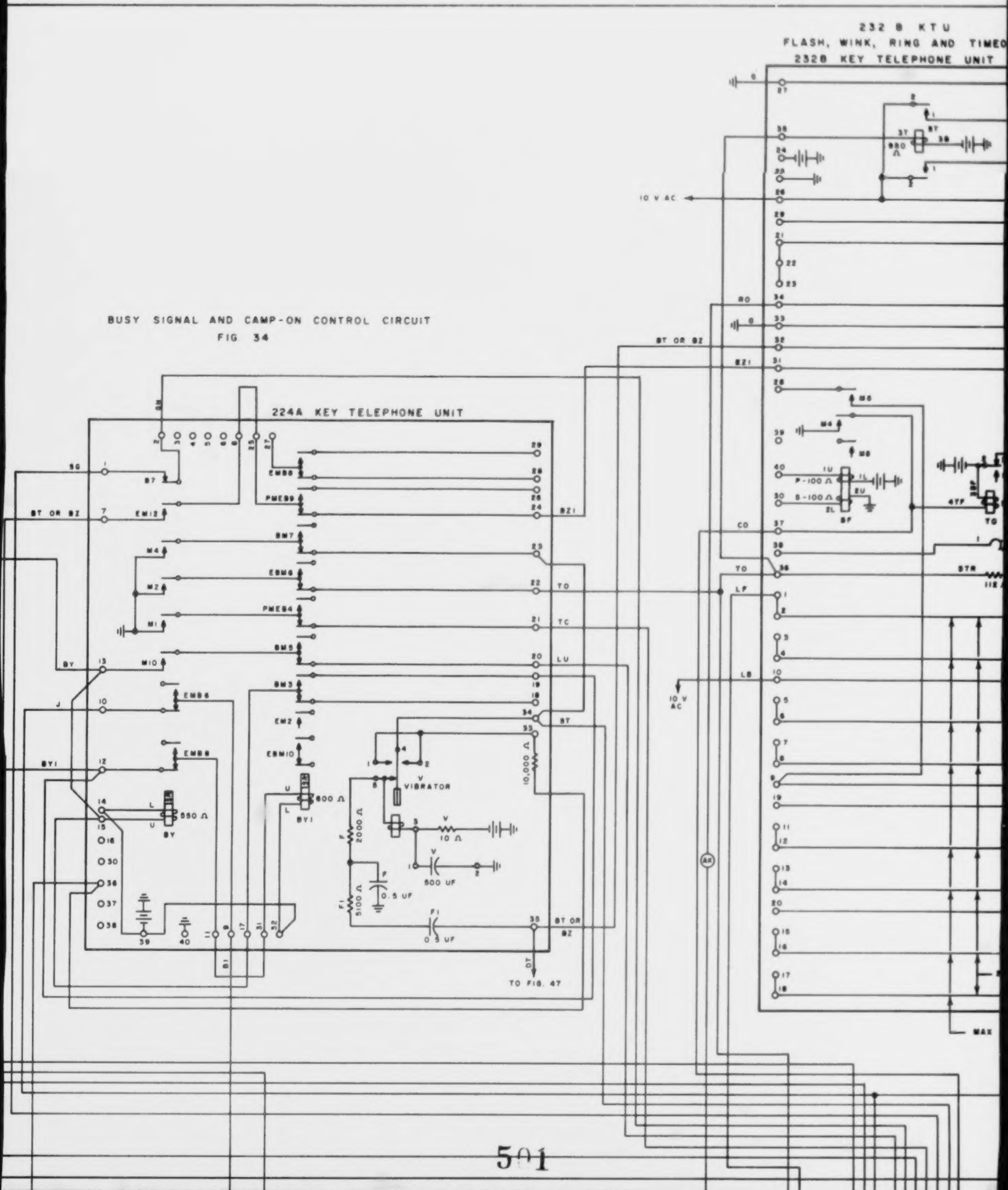

POWER VAN
J53033C
EQUIPMENT CABINET
J53009CV
CO
-24V (A13)
1L
1U
TSB
23
CO
-24V (A13)
BM8
21
B
TO 1ST, 3RD & 5TH DIODE CIRCUITS FOR POS 1 ON ED69428 (FIG. 4)
B
TSB
14
BM6
-24V (A13)
834A NETWORK
3
R3
TO 2ND, 4TH & 6TH DIODE CIRCUITS FOR POS 1 ON ED69428 (FIG. 4)
B
24
B7
-24V (A13)
(A13)
M10
2
2
1
Q1
R5
4
11
C
R2
R6
1
Q2
(A13)
R1
TO POS 1 LINE OR BUSY LAMPS (FIG. 4)
D
D
TO POS 1 HOLD OR SUPV LAMPS FIG. 2, SH 2
D
TSC-56
TO REQUESTING POS 1 KEY & LAMP UNIT (FIG. 8)
D
TSB-13
D


OPERATIONS VAN
J53033E
DIAL UNIT ASSEMBLY
POS 1
POS 1
POS 1
LP CONT
AV
AV
CO
5
32
5
2
1
A13)
OFF
ON
AT
AT
B
31
R6
AX
AX
C
33
3
1
R4
2
LP CONT
AW
AW
D
8

Foldout 7. Dark environment lamp control circuit.

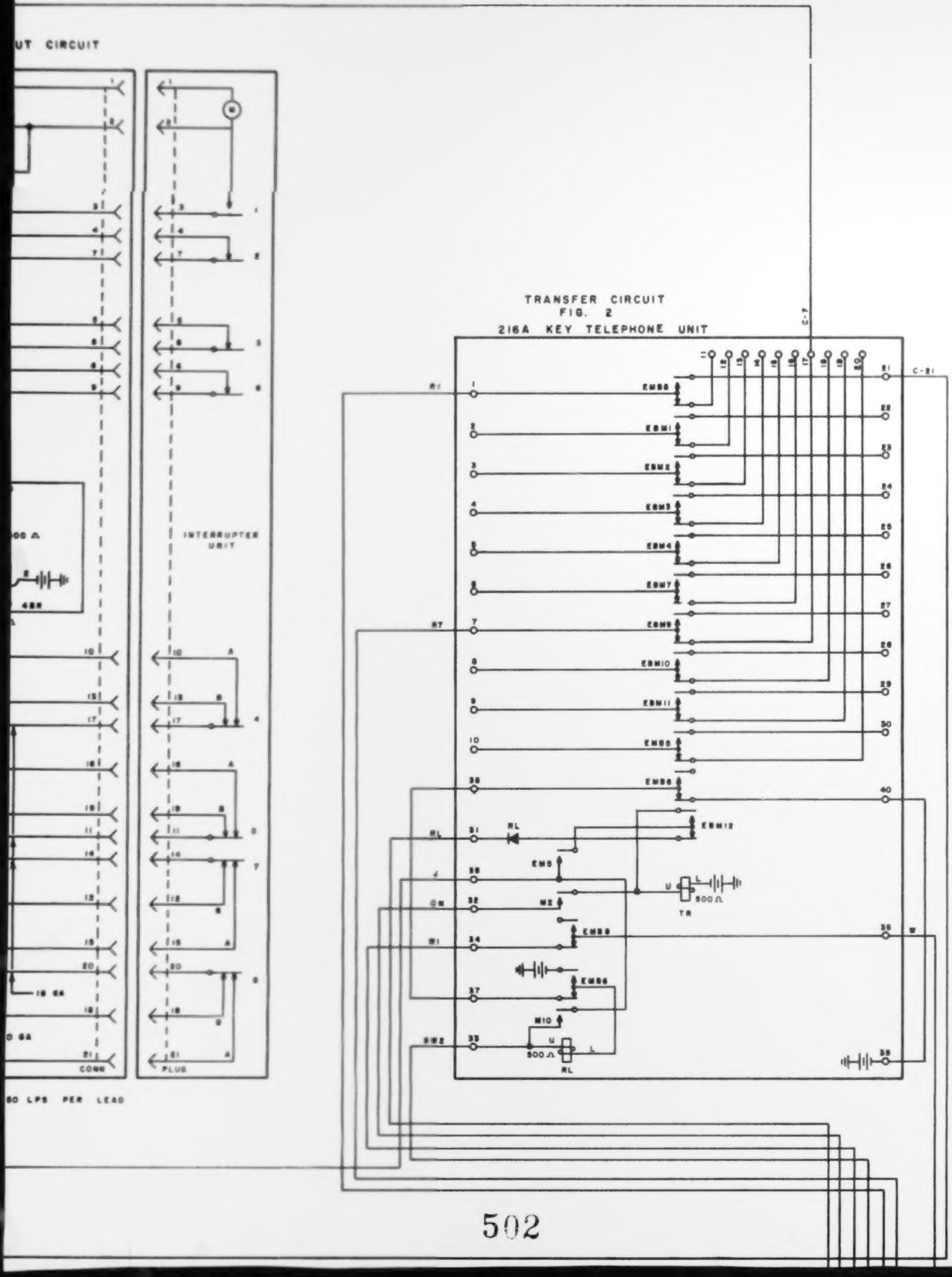

STATION SIGNALING CIRCUIT
(TWO TALKING LINKS)
FIG. 28

223A KEY
TELEPHONE UNIT
STATION 7
T
R
C7
31A
32A
F
T
A
R
B
L
100 Ω
-4
+1
100 Ω
PMEB4
PMEB9
EM2
2
3
5
BM5
BM3
EBM6
BM7
EBM10
EBM8
EM2
1B
T2
33A
T1
2B
R2
34A
R1
38A
H
7B
BY
40A
6B
LB
37A
LF1
H
RS2
9B
A2
39A
A1
TO LAMP
AT TEL
L
LG
C
D
TH
3B
4B
TO OTHER
STA SIG CKTS
TO AUD
SIG Z
R1
B1
B
6
RG
E
4A
14A
24A
U
SR
L
600 Ω
LS
L
U
600 Ω
LT
TO OTHER
STA SIG
CKTS
8A
36A
5B
6B
10B
17B
18B
19B
20B
10A
35A
K
J
9A
LB
TO POWER SUPPLY
FOR RINGERS
Z
Z

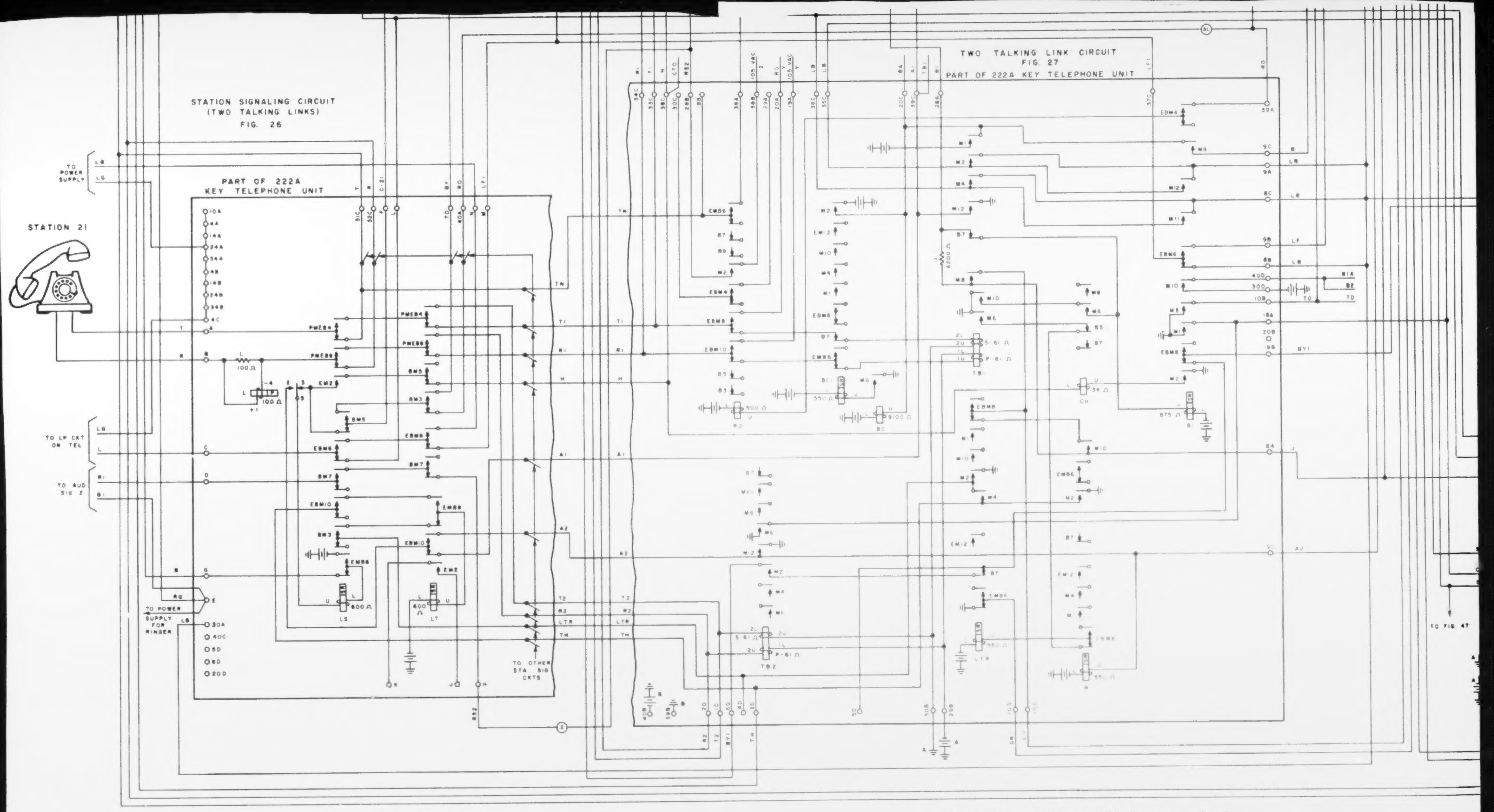


BUSY SIGNAL AND CAMP-ON CONTROL CIRCUIT
FIG 34

232 B KTU
FLASH, WINK, RING AND TIMED
232B KEY TELEPHONE UNIT
224A KEY TELEPHONE UNIT
10 V AC
RO
BT OR BZ
BZ1
CO
TO
LF
LB
SG
BT OR BZ
BY
J
BY1
B7
EM12
M4
M2
M1
M10
EMB5
EMB8
EMB8
PMEB9
BM7
EBM6
PMEB4
BM5
BM3
EM2
EBM10
BZ1
TO
TC
LU
BT
BT OR BZ
DT
TO FIG. 47
550 Ω
BY
600 Ω
BY1
V
VIBRATOR
F 2000 Ω
F1 5100 Ω
F 0.5 UF
F1 0.5 UF
V 10 Ω
V 500 UF
10,000 Ω
B1
P-100 Ω
S-100 Ω
BF
1U
1L
2U
2L
M6
M4
M8
980 Ω
BT
47F
TG
STR
AK
MAX


UT CIRCUIT
INTERRUPTER UNIT
500 Ω
48R
CONN
PLUG
60 LPS PER LEAD
10 GA
18 GA
R1
R7
RL
ON
W1
SW2
EMB8
EBM1
EBM2
EBM3
EBM4
EBM7
EBM9
EBM10
EBM11
EMB5
EMB6
EBM12
EM5
M2
M10
U
L
500 Ω
TR
RL
C-7
C-21
W
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

TRANSFER CIRCUIT
FIG. 2
216A KEY TELEPHONE UNIT


STATION SIGNALING CIRCUIT
(TWO TALKING LINKS)
FIG. 26
TWO TALKING LINK CIRCUIT
FIG. 27
PART OF 222A KEY TELEPHONE UNIT
PART OF 222A
KEY TELEPHONE UNIT
STATION 21
TO POWER SUPPLY
TO LP CKT ON TEL
TO AUD SIG Z
TO POWER SUPPLY FOR RINGER
TO OTHER STA SIG CKTS
TO FIG. 47

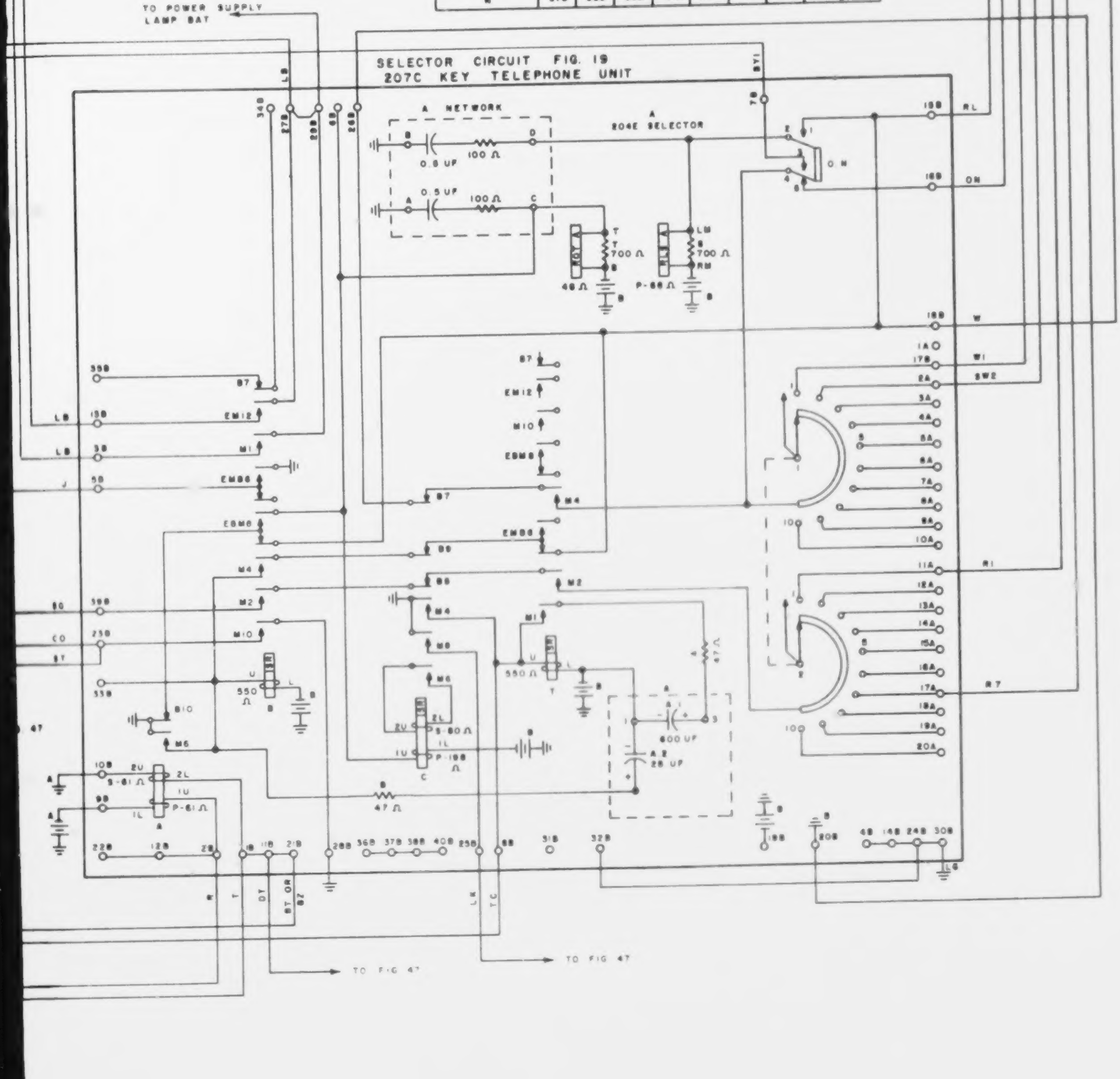
Foldout 3. Schematic diagram of 6A key system circuits.

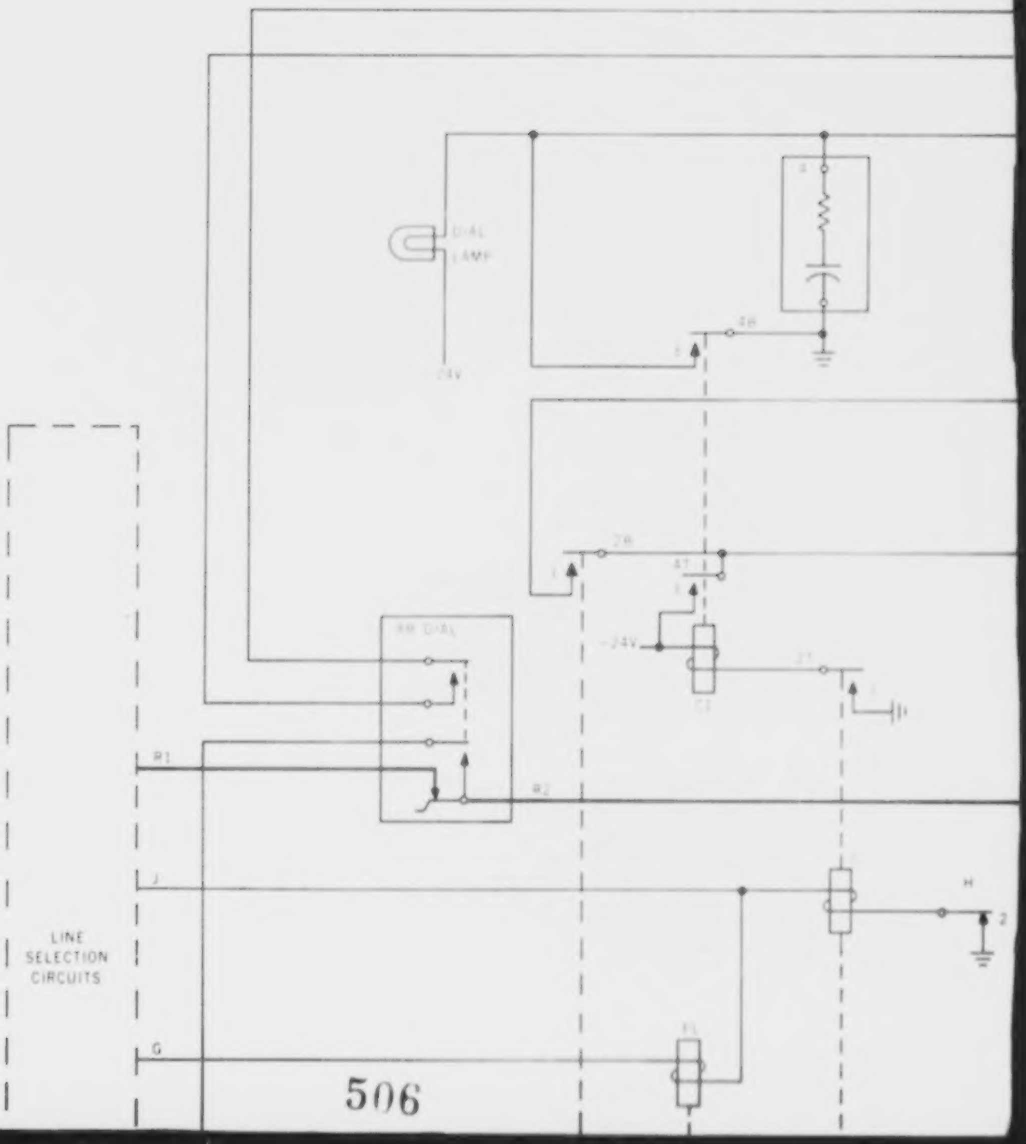
36254 04 S02 8102

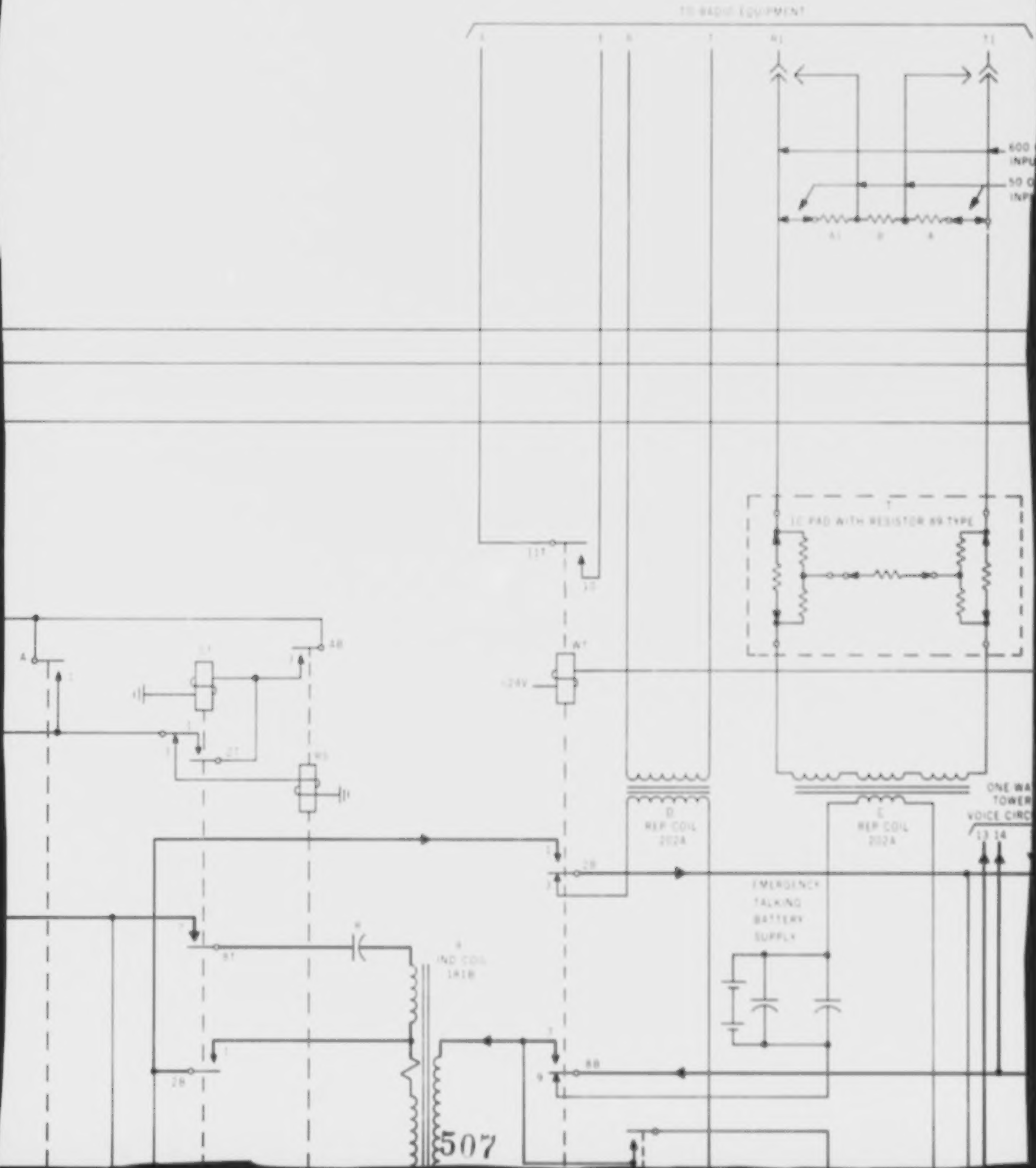
Foldout 3

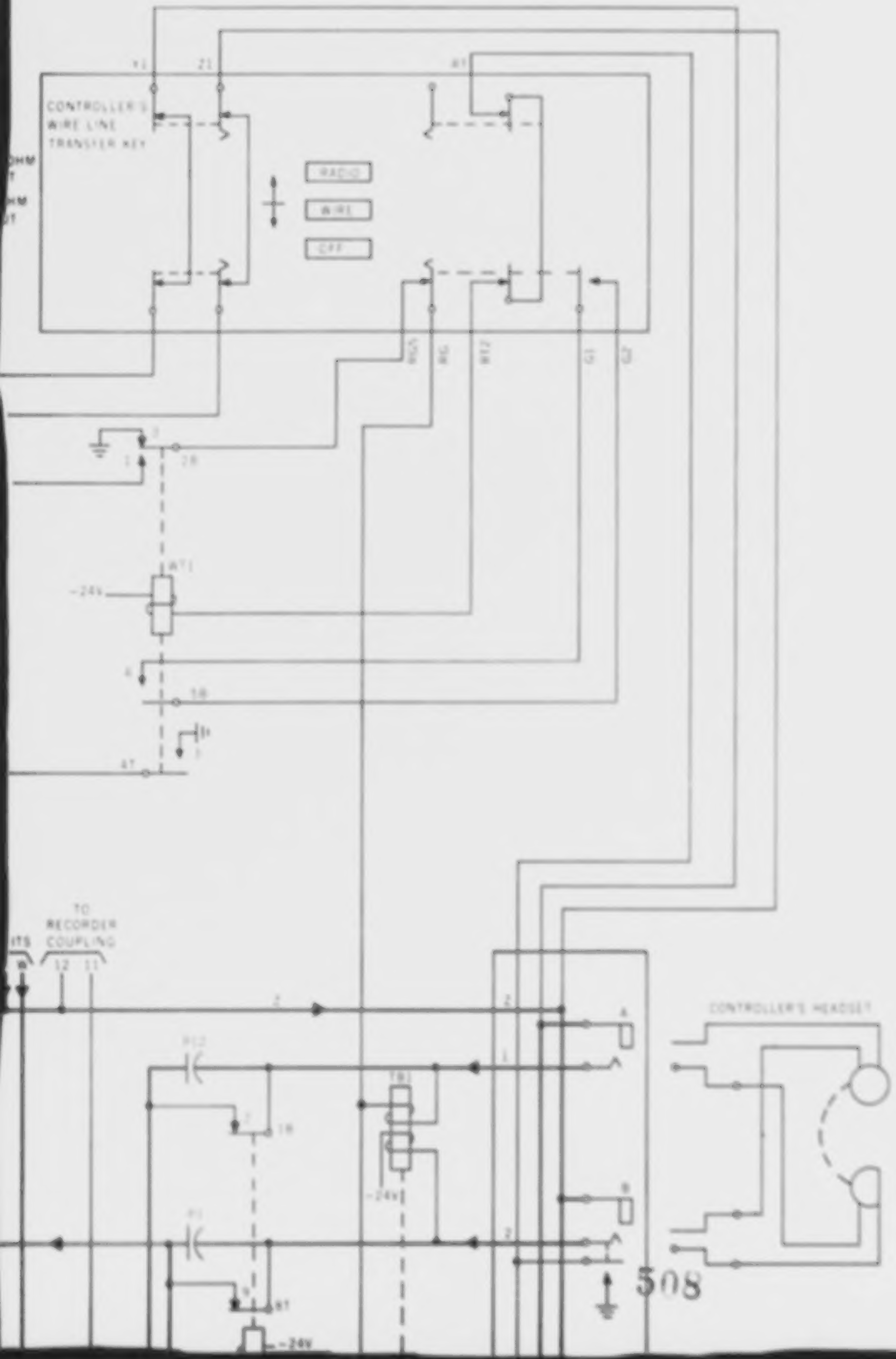
AU GAFS AL(852317)800

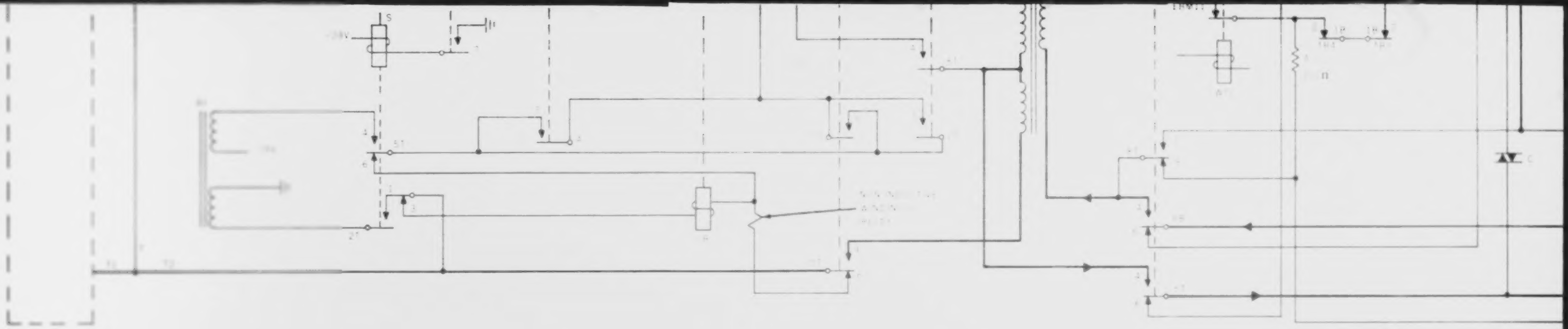
REFERENCE DESIGNATION	PUNCHING								
	CKT 1	CKT 2	CKT 3	CKT 4	CKT 5	CKT 6	CKT 7	CKT 8	CKT 9
A	1A	11A	21A	31A	1B	11B	21B	31B	1C
B	2A	12A	22A	32A	2B	12B	22B	32B	2C
C	3A	13A	23A	33A	3B	13B	23B	33B	3C
D	5A	15A	25A	35A	5B	15B	25B	35B	5C
E	6A	16A	26A	36A	6B	16B	26B	36B	6C
F	7A	17A	27A	37A	7B	17B	27B	37B	7C
G	11C	12C	13C	14C	15C	16C	17C	18C	19C
H	21C	22C	23C	24C	25C	26C	27C	28C	29C
J	11D	12D	13D	14D	15D	16D	17D	18D	19D
K	21D	22D	23D	24D	25D	26D	27D	28D	29D
L	31D	32D	33D	31D	32D	33D	31D	32D	33D
M	34D	35D	36D	34D	35D	36D	34D	35D	36D
N	37D	38D	39D	37D	38D	39D	37D	38D	39D


TO POWER SUPPLY
LAMP BAT
SELECTOR CIRCUIT FIG. 19
207C KEY TELEPHONE UNIT
A NETWORK
0.5 UF
100 Ω
A
204E SELECTOR
700 Ω
48 Ω
P-88 Ω
O.N
RL
ON
W
W1
SW2
R1
R7
LB
J
SG
CO
ST
550 Ω
S-80 Ω
P-198 Ω
S-61 Ω
P-61 Ω
47 Ω
600 UF
2 UF
28 UF
R
T
DT
ST OR 87
LK
TC
TO FIG 47
TO FIG 47


DIAL
LAMP
24V
8
4B
1
2B
4T
1
-24V
CT
2T
1
RR DIAL
R1
R2
J
H
2
LINE
SELECTION
CIRCUITS
G
FL


TO RADIO EQUIPMENT
R1
T1
600
INPU
50 O
INP
A1
A
T
1C PAD WITH RESISTOR 89 TYPE
A
48
LT
27
WS
W1
-24V
11T
10
2B
D
REP COIL
202A
E
REP COIL
202A
ONE WA
TOWER
VOICE CIRC
13 14
EMERGENCY
TALKING
BATTERY
SUPPLY
8T
IND COIL
101B
2B
8B
9


CONTROLLER'S WIRE LINE TRANSFER KEY
Y1
Z1
X1
RADIO
WIRE
OFF
WG
WT2
G1
G2
2B
WT1
-24V
1B
4T
TO RECORDER COUPLING
12
11
ITS
Z
R12
TB1
-24V
R1
8T
-24V
A
B
1
2
CONTROLLER'S HEADSET

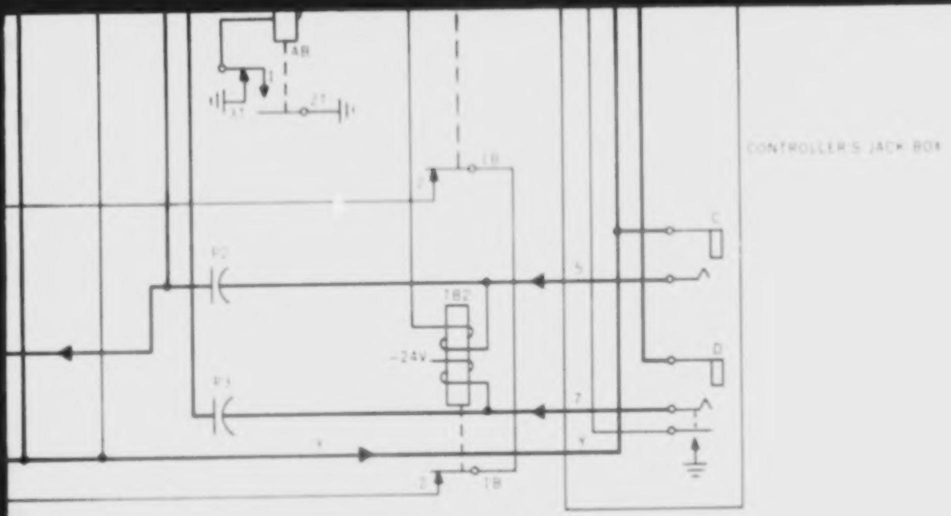

S
+28V
51
27
A1
NON-INDUCTIVE
WINDING
RELAY

Foldout 5. Schematic diagram for controller's radio and wire-line termination equipment.

36254 04 S03 8102

Foldout 5

AU GAFS AL [illegible]


AB
1
1T
2T
CONTROLLER'S JACK BOX
1B
2
C
P2
5
1B2
-24V
D
P3
7
Y
Y
2
1B

STOP - 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

36254 04 23
KEY TELEPHONE SYSTEMS

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet .
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

Note to Student: Consider all choices carefully and select the best answer to each question.

1. (600) A modern key telephone system will ordinarily provide

   a. three to seven talking circuits distributed among five to fifteen stations.
   b. two to four talking circuits distributed among five to ten stations.
   c. three to fifteen lines distributed among five to fifteen stations.
   d. five to fifteen lines distributed among three to seven stations.

2. (601) Prearranged key telephone units developed for a specific system are referred to as a

   a. PBX.
   b. package.
   c. central office.
   d. telephone station.

3. (601) Audible signaling for a key system is provided by

   a. the 202D unit.
   b. the 230B unit.
   c. the CAMP-ON CONTROL unit.
   d. an electromechanical interrupter.

4. (602) Which of the following features are provided by the 202D KTU?

   a. PICKUP and visual supervision for one line.
   b. PICKUP and visual supervision for four lines.
   c. Intermittent ringing and power failure alarm for one line.
   d. Intermittent ringing and power failure alarm for four lines.

5. (602) Which of the following KTY's provides dial selective intercom for a 200G7DC package?

   a. KS-19175.
   b. 400B.
   c. 207C.
   d. 202D.

6. (603) Text figure 1-8 shows the power failure transfer circuit as the

   a. 420A KTU having 40 pins.
   b. 421A KTU having 18 pins.
   c. 420A KTU having 28 pins.
   d. 421A KTU having 40 pins.

7. (603) Text figure 1-11 shows the connecting blocks to be

   a. 66R3 (long) and 66R1 & R2 (short).
   b. 66R3 (short) and 66R1 & R2 (long).
   c. 66R3 & R2 (short) and 66R1 (long).
   d. 66R3 & R1 (long) and 66R2 (short).

8. (604) An 18-station key system requires

a. exclusion key operation and two-digit dialing for intercom selection.
b. exclusion key operation and one-digit dialing for intercom selection.
c. one-digit dialing for PBS and intercom selection.
d. two-digit dialing for intercom selection.

9. (605) In a key system, amphenol connectors are now used on

a. call directors with EXCLUSION keys only.
b. bridging terminals.
c. connecting blocks.
d. mounting cords.

10. (605) What operation must you perform at a 560-type telephone set if you are able to talk with a person over a central office line?

a. ROTATE EXCLUSION key clockwise.
b. Operate a TALK-LISTEN switch.
c. Depress a pushbutton.
d. Dial 9.

11. (605) The key commonly used in key telephone systems to permit a station to cut out all other stations is the

a. EXCLUSION.
b. CUTOFF.
c. PICKUP.
d. HOLD.

12. (605) What purpose does the EXCLUSION switch on the 565 key telephone serve?

a. Restores all PICKUP keys.
b. Provides privacy for all lines.
c. Provides the user with one private line.
d. Permits all stations to have more privacy.

13. (605) See figure 1-14. A 564HL telephone set has

a. five pushbuttons.
b. no speaker-phone control.
c. four channels for communications.
d. cutoff without the exclusion feature.

14. (606) The maximum number of buttons which may be installed on a CALL DIRECTOR 630 telephone set is

a. 6.
b. 12.
c. 18.
d. 30.

15. (607) Foldout 1 shows positive dc battery connected at terminal

a. 24, 232B KTU.	c. 26, 230B KTU.
b. 25, 232B KTU.	d. 29, 230B KTU.

16. (608) Foldout 1 shows that the metallic ringing source is connected at terminals

a. 1R and 2R, 564 telephone set.
b. 24 and 25, 232B KTU.
c. 9 and 10, 230B KTU.
d. 7 and 8, 230B KTU.

17. (609) See foldout 1, the 564 telephone set lamp interruptions result from

a. alternate opening and closing of interrupter contacts 2.
b. alternate opening and closing of interrupter contacts 4 and 5.
c. intermittent opening and closing of hookswitch contacts F and G.
d. intermittent opening and closing of hookswitch contacts A and B.

18. (610) Foldout 1 shows that the operated relay in a 1A1 key system which causes the signal lamp to burn without flashing is relay

a. A in the 230B KTU.	c. ST in the 232B KTU.
b. R in the 230B KTU.	d. TO in the 232B KTU.

19. (611) Tracing foldout 1, what hookswitch contacts complete the A1-A telephone relay circuit?

a. A and B.	c. D and E.
b. B and C.	d. F and G.

20. (612) What installation method prevents operation of relay H in the 230B KTU? (See foldout 1.)

a. Shunt formed by contacts B4 at relay AH.
b. Shunt formed by contacts F and G at hookswitch.
c. Open at contacts M8 of released relay H.
d. Open at contacts EBM12 if released relay A.

21. (613) Select the relays and contacts that enable outgoing calls from the telephone during power failure.

a. Operated relay A, contact EBM12 and released relay AH, contact B4.
b. Operated relay AH, contact B4 and released relay A, contact EBM12.
c. Operated relay AH, contact B4 and operated relay A, contact B9.
d. Released relay A, contact B9 and released relay AH, contact B4.

22. (614) Foldout 2 shows which terminal connected to the negative side of the dc power source?

a. 19B.
b. 20B.
c. 24B.
d. 40B.

23. (614) Foldout 2 shows that the operated rotary magnet in the Dial Selective Intercom Unit causes

a. relay A to release.
b. the release magnet to operate.
c. the stepping switch to restore.
d. the stepping switch to operate and, in turn, it operates the O.N. switch.

24. (615) The 1A2 key system circuit component that operates while all telephone station handsets are on the cradle is

a. transistor Q2.
b. transistor Q1.
c. relay A.
d. relay B.

25. (616) See figure 2-1. The 400D KTU transistor operating sequence is (See figure 2-1.)

a. Q1, Q2, Q3 then Q2 and Q3 release Q1.
b. Q2, Q1, Q3 then Q2 releases Q1 and Q3.
c. Q1 releases, Q2 operates followed by Q3.
d. Q1 releases, Q2 operates and releases to operate Q3.

26. (617) The purpose of RT1-RT2 resistor network is to

a. reset the "B" relay release time.
b. prevent release of the B relay.
c. control duration of time-out.
d. prevent a false time-out.

27. (618) Text figure 2-1 shows that which of the following 1A2 key system circuit components are operated during a conversation?

a. Relays A, B, and C only.
b. Relays A and C plus transistor Q1.
c. Relays B and C plus transistor Q2.
d. Relays A, B and C plus transistors Q1 and Q2.

28. (619) What 400D KTU components are in the telephone line loop during the HOLD period?

a. R1 and relay A.
b. R2 and relay L.
c. R1 and relay L.
d. R2 and C3.

29. (620) During circuit "BUSY" condition, what is the status of the 400D KTU transistors?

a. Q1, Q2 and Q3 operated.
b. Q1, Q2 and Q3 released.
c. Q1 released, Q2 and Q3 operated.
d. Q1 operated, Q2 and Q3 released.

30. (621) What 400D KTU components are normally in the line loop in case of power failure? (See figure 2-1.)

a. A relay winding and strapping between 2 terminals.
b. B relay contacts and strapping between 3 terminals.
c. C relay contacts and strapping between 4 terminals.
d. L relay winding and R2 and strapping attached at 1 terminal.

31. (622) See foldout 3. The vibrator of the 224 KTU operates because of a strap extending between

a. punching 34 of KTU 224 and punching of 23B of KTU 207C.
b. punching 34 of KTU 224 and punching 8B of KTU 207C.
c. contacts M1 and M2 of relay BY.
d. punchings 23 and 35.

32. (622) Which of the following relays must operate in order that the lamps will flash for a key telephone installed in a 6A key system? (See foldout 3.)

a. Relays A, B, C and T in KTU 207C and the vibrator in the 224A KTU.
b. Relays B1, TB1, TB2, L, LS, and LT in KTU 222A, and relay ST in the 232B KTU.
c. Relays A and B in KTU 207C, relays B1 and LS in KTU 222A, and relay ST in the 232B KTU.
d. Relays A and B in KTU 207C, relays B1, LS, L, and LT in KTU 222A, and relay M in KTU 232B.

33. (623) Tracing foldout 3, the operated relays and associated contacts that complete the operating circuit of relay TR in the 216A KTU are

a. M2 of ON, M2 of T, B5 of C and EBM6 of relay LTR in the 222A KTU.
b. M2 of RL, 4 and 5 of ON, M10 of R1 and M2 of relay H in the 222A KTU.
c. EBM12 of TR, EM5 of RL, and EBM8 or relay B in 207C KTU.
d. M2 of RL, M4 of T, and B7 of relay C in the 207C KTU.

34. (624) Relay LS in the 222A KTU operates because of

a. a decrease in resistance as a result of operated contact M2 on relay BC1.
b. an increase in resistance as a result of operated contact M2 on relay BC1.
c. a decrease in current as a result of operated contact M2 on relay BC1.
d. 105 volts alternating current being connected to its windings by contact M1 of operated relay TB1 and operated contact M9 of relay B1 in KTU 222A.

35. (625) Use foldout 3 and determine which relay contact completes the direct current circuit to the connected telephone stations of a 6A key system,

a. M12 of relay TB2 in KTU 222A.
b. EMB6 of relay RO in KTU 222A.
c. EMB6 of relay LS in KTU 222A.
d. EMB6 of relay BC1 in KTU 222A.

36. (625) Which of the following conditions normally result at time of "automatic cutoff" for the 6A system equipment?

a. Busy relays operate to prevent any calls from being originated.
b. Adequate equipment remains operated to keep two lamps flashing.
c. Adequate equipment remains operated to keep two stations connected for conversation.
d. Relay TB1 is operated, thus keeping relay TB2 from operating until relay ST starts the interrupter.

37. (626) How is a CAMP-ON request selected?

a. By depressing the SIGNAL key and intercom key simultaneously.
b. Through use of a dialed code number.
c. By depressing the exclusion key.
d. Through use of a SIGNAL key.

38. (627) An operated conference pushbutton does which of the following?

a. Provides dial pulses to the 207C KTU.
b. Provides negative battery to relays TB1 and TB2 in the 222A KTU.
c. Makes direct contact with terminals for many stations, thus completing their talking circuits.
d. Completes a relay circuit which, in turn, makes additional relay circuits, thereby resulting in connections for several stations.

39. (627) Using text figure 2-29 and foldout 3, what KTU terminal interconnection provides the operating circuit for relay R01 in the 217A KTU?

a. Terminal 7 for 217A and 19B in the 222A KTU.
b. Terminal 17 for 217A and 19B in the 222A KTU.
c. Terminal 29 for 217A and 40D in the 222A KTU.
d. Terminal 39 for 217A and 30D in the 222A KTU.

40. (628) What KTU has the relay that connects the positive potential to the 217B KTU for operating its time-out relays?

a. 223A.
b. 222A.
c. 217A.
d. 207C.

41. (629) For a 2000-line telephone system, the number of simultaneous calls that may normally be made is

a. 10.
b. 20.
c. 200.
d. 1000.

42. (630) When preparing to install a 36 station key telephone system, how many additional stations should be planned for typical growth over a five year period?

a. 4.
b. 8.
c. 14.
d. 30.

43. (631) KTU's to order for a typical 6A key system would probably include the 217B, 222A, 223A, 224A,

a. 227A, Signal Tone Control, and 207C, Dial Selective Intercom units.
b. RT-1B, powerplant, and 401A, Dial Selective Intercom.
c. 101G, powerplant, and 401A, Dial Selective Intercom.
d. 230B, CO Line Unit, and 551A, Key Service Unit.

44. (632) Refer to figure 3-3 of the test and select the telephone tip and ring color coded conductors for line 3. They are colored

a. white-brown and brown-white.
b. red-orange and orange-red.
c. red-slate and slate-red.
d. red-green and green-red.

45. (633) Which of the following room conditions would be most apt to cause telephone equipment outages?

a. Limited light.
b. Excessive space.
c. Inside wiring.
d. Excessive heat.

46. (634) Usually, the first equipment cable for the telephone system to be connected is the

a. key cable.
b. power cable.
c. running cable.
d. grounding cable.

47. (635) Which of the following installation procedure violations can result in causing an open circuit?

a. Wrapping a wire around a screw terminal in a clockwise direction.
b. Wrapping a 1-3/4 loops of wire around a screw terminal.
c. Placing one wire under each washer.
d. Placing slack at each connection.

48. (636) Using text figure 3-6, what colors will you find in a cable for pair 42?

a. Orange and yellow in an orange-white binder.
b. Orange and yellow in a blue-white binder.
c. Orange and black in a green-white binder.
d. Orange and white in a brown-white binder.

49. (637) When placing the key system cable, which of the following rules is NOT a good procedure?

a. For safety sake, always have someone at the cable reel while cable is being withdrawn.
b. To reduce waste, compare the length of the cable on the reel to the requirements.
c. To save time, cut cables to the required length shown on the cable running list.
d. To prevent damage to cable, avoid sharp bends when cable is running free.

50. (638) Separating pair conductors and positioning each at the specified terminal is called

a. fanning and terminating.
b. bridging and attaching.
c. forming and connecting.
d. ringing and butting.

51. (639) When preparing to butt a key cable, you must take note of the

a. cable radius to determine the size of the tool to use.
b. sheath construction to determine the type of cutting tool required.
c. position of the terminal strips to determine the location of the butt.
d. cable sag and position of the clamps to determine if a butt is needed.

52. (640) A probable trouble at an interior cable butt is an open caused by

a. moisture on the sheath.
b. a broken conductor.
c. plastic tie pull
d. rip cord pull.

53. (641) Using text figure 3-6, which of the following color coded key cable pairs would you cut shortest before installing it on a 66-type bridging terminal?

a. Green-violet.
b. Slate-red.
c. Slate-black.
d. Green-red.

54. (642) How much bare metal is "shiner" when the skinned wire is 1/2 inch long?

a. 1/2 inch.
b. 1/4 inch.
c. 2/16 inch.
d. 3/8 inch.

55. (642) What color is the wire attached to the left terminal in row 6 of the bridging terminal of figure 3-10? (Also, refer to text figure 3-6.)

a. Green-white.
b. White-brown.
c. Blue-white.
d. Red-slate.

56. (643) Using figure 3-3, determine the row of a 66-type connecting block in which the L lead for line 5 should be terminated. It is

a. row 25.
b. row 27.
c. row 28.
d. row 30.

57. (644) What portion of a solder lug do you use to mark the insulation for removal?

a. Notch.
b. Base.
c. Bend.
d. Face.

58. (645) When making an operational test of a 1A1 key system, it is sufficient to test

a. one phone for all features, with other instruments of the system in use.
b. each phone, one at a time, for all features and service.
c. one phone for hold.
d. one phone for traffic count only.

59. (646) Which of the following symptoms shall be noted at an excluded station?

a. No sidetone can be heard but dial tone is audible.
b. Sidetone can be heard but dial tone cannot be.
c. No sidetone nor dial tone can be heard.
d. Sidetone and dial tone can be heard.

60. (647) What connecting method provides lamp flashing at each telephone of a 1A1 key system following incoming signaling?

a. Series.
b. Parallel.
c. Strapping of MDF at central office.
d. Strapping of terminals on rotary switch.

61. (648) What operational symptom is to be expected with the CAMP-ON feature?

a. Intermittent ring.
b. Lamp wink.
c. Busy tone.
d. Silence.

62. (649) Which of the following sounds may be a "signaling out" symptom?

a. Dial tone.
b. Busy tone.
c. Bell tapping.
d. Scratching and sizzling.

63. (650) A telephone trouble that requires time for visual searching is

a. a solid short-circuited connection.
b. an intermittent connection.
c. an open indicator lamp.
d. an open relay contact.

64. (651) Key system short-circuits cause

a. open lamps.
b. open relay windings.
c. an increase in circuit current.
d. an increase in circuit resistance.

65. (652) When the trouble report is "gets wrong numbers," the probable trouble is

a. relay TB1 in the 222A KTU is operated.
b. relay A in the 230B line circuit is open.
c. contact EBM10 of relay LT in the 222A KTU is open.
d. contact B10 of relay A in the 207C KTU is incorrectly adjusted.

66. (653) What procedure should be undertaken first when troubleshooting key system equipment?

a. Analysis of the trouble report.
b. Component replacement.
c. Test equipment checks.
d. Visual inspection.

67. (654) Typical crew activities that follow reception of a key system trouble report are the operational check of at least two pushbutton circuits, analysis of the operational symptoms, and

a. assigning and listing trouble codes.
b. tracing and analysis of circuit diagrams.
c. assigning report numbers and filing reports.
d. analyzing circuit diagrams and modifying circuit routing.

68. (655) Telephone equipment troubles are

a. mainly electrical.
b. permanently restored.
c. automatically recorded.
d. mostly mechanical types.

69. (656) The space between the relay core and the closest projection of the armature for relay A shown in table 4-1 is

a. .022 inch.
b. .026 inch.
c. .0249 inch.
d. .0098 inch.

70. (657) The key system rotary switch is tested for

a. mechanical failure and is corrected by adjusting the current flow.
b. mechanical failure and is corrected by replacing the switch winding.
c. electrical deviations and is corrected by adjusting the current flow.
d. electrical deviations and is corrected by adjusting the mechanical components.

71. (658) What procedures enable open conductors to be identified?

a. Reactance and capacitor-inductance resonance testing.
b. Jumper wire and short-circuit substitution methods.
c. Jumper wire substitution and resistance testing.
d. Oscilloscope and multimeter balance testing.

72. (659) Shorts at solderless terminals may be caused by

a. maladjusted relay contacts.
b. parallel resistors.
c. pigtails.
d. fuses.

73. (660) What is the characteristic of a good replacement cross-connection strap?

a. Shaped like the former and with 0 ohms resistance.
b. Shaped like the former and with infinite resistance.
c. Shaped to fit a new routing and with 4-inches of slack.
d. Shaped to fit a new routing and with infinite resistance.

74. (661) Proficiency of your crew should result from troubleshooting procedures used in the operation of equipment for

a. analysis of data and condemnation.
b. verification and analysis of circuits.
c. repetitive inspection and periodic testing.
d. logical interpretation and positive advice.

75. (662) The operated 302 equipment pushbuttom which disconnects the headset from the station line is the

a. dark environment control.
b. flash and ring key.
c. LP control.
d. RLS key.

76. (663) Which of the following lamps cannot operate again if its associated key is operated while the RED lamp is glowing?

a. GREEN.
b. WHITE.
c. AMBER.
d. ON.

77. (664) You complete the one-way voice circuit between the operations van and the control tower by operating the

a. transfer key (wire and radio).
b. turn switch COM.
c. push key LINE.
d. push key PTT.

78. (665) Relay TB1 for the 302 Switching Unit is installed in the

a. equipment cabinet at the power van.
b. J53033P-1 unit at the operations van.
c. J53009CY-1 unit at the operations van.
d. telephone relay rack at the control tower.

79. (665) Text figure 5-6 shows that the visual signaling for the operation's van and control tower is

a. one-way for both facilities.
b. two-way for both facilities.
c. two-way for tower, one-way for operations van.
d. two-way for operations van, one-way for tower.

80. (666) Using foldout 4, which contacts of the operated relays complete the talking circuit between the telephone station and the controller's headset?

a. EMB6 and EMB8 of relay FR and EMB4 and EMB1 of relay SL.
b. EMB12 and 2 of relay L and EMB1 and EMB8 of relay SL.
c. 8T and 9T of relay WT and 2T and 3T of relay CT.
d. 1T and 2T of relay S and 5B and 6B of relay CT

81. (667) You can release a station line for a 302 Switching system by

a. operating the HOLD key.
b. operating the transfer key to WIRE.
c. operating the LINE key serving the central office.
d. inserting a second headset into jacks C & D of J53033P-1.

82. (668) See foldout 5. While the dial is being operated, the 302 Switching Unit headset receiver

a. can not operate because current can not flow within an open circuit.
b. operates with increased strength because of increased current.
c. operates with increased resistance and decreased current.
d. can not operate because current is shunted around it.

83. (669) Foldout 4 shows the holding circuit for relay H for a station line signaling circuit to include contacts 2T of relay H and

a. 12 of relay SL.
b. 5 of relay SL.
c. 5T of relay A.
d. 2 of relay L.

84. (670) Using foldout 4, you can determine that the depressed RLS key releases

a. the line key and relays CR1 and CR2.
b. the 30-cycle ac source.
c. relays SL, A, and H.
d. relays WT1 and WT2.

85. (671) The operated key that disconnects the GCI station voice line from the 106B loudspeaker is the

a. transfer key.
b. LINE key.
c. PTT key.
d. PAR key.

86. (672) Using foldout 7, which contact places ground on the D leads for the LINE or BUSY lamps following operation of the LP CONT switch to OFF?

a. 1 on switch LP CONT.
b. 2 on switch LP CONT.
c. M10 on operated relay CO.
d. M10 on released relay CO.

87. (672) Using foldout 6, which contact connects holding ground to relay A3 in the J53033M unit?

a. EBM12 on relay B03 in the J53033B unit.
b. EMB8 on relay B02 in the J53033B unit.
c. 12 on relay FL1 in the J53033M unit.
d. 4T on relay A in the J53033M unit.

88. (673) What relays in the J53033B unit are revealed to be good when the RED lamp lights steadily following a performance test at the operations van?

a. A1, A2, K1, K2.
b. FL, A3, K3, B03, BR3.
c. FL, A4, K4, B04, BR4.
d. AC4, FL, A1, A2, A3, A4, K4.

89. (674) Relay CH in the control tower operates

a. with more dc current as a result of the simplex circuit connection.
b. with more ac current as a result of the simplex circuit connection.
c. because a shunt circuit is completed by the operated PTT and RED keys.
d. because the operated GREEN key shunts the ON and RED keys.

90. (675) Radio communications to and from the operations van are normally the responsibility of the

a. controller using the COM switch.
b. controller using the transfer key.
c. assistant controller using the COM switch.
d. assistant controller using the transfer key.

91. (676) See foldout 6. Which of the following units will you inspect at the operations van but not at the power van?

a. J53033F.	c. J53033A.
b. J53033B.	d. J53009CR.

92. (677) Information about operating performance routines are kept

a. on pink cards.
b. on green cards.
c. in the equipment cabinet of the power van.
d. above the telephone relay rack in the control tower.

93. (678) The simplest and quickest method of returning the 302 Switching Unit to full operation is to

a. replace low ampere fuses with high ampere fuses.
b. replace suspect units with units known to be good.
c. disconnect connecting cables, change vans and restore the connecting cables.
d. call depot maintenance for the master listing of all standard, common troubles experienced in the field.

94. (679) A telephone system specialist will

a. replace low ampere fuses with high ampere fuses.
b. replace high ampere fuses with low ampere fuses.
c. wipe relay springs to one gram value below that specified.
d. not move relay springs until all tests prove that they are maladjusted.

95. (680) Using text figure 6-1, which of the listed equipment numbers applies to the NO. 2 telephone set?

a. TA-883.	c. BZ-201.
b. TA-884.	d. PP-6839.

96. (681) What is the location of the voltmeter and what voltage should it reflect?

a. Switchboard and 33 dc volts.
b. Switchboard and 33 ac volts.
c. Power supply and 33 ac volts.
d. Power supply and 33 dc volts.

97. (682) Which of the following amplifiers has an inverted signal at the output from that at the input?

a. Class B.	c. Common-emitter.
b. Grounded-base.	d. Emitter-follower.

98. (683) A common-emitter transistor would be used in which of the following electronic circuits?

a. AND gate.	c. Zener regulator.
b. NAND gate.	d. Power rectifier.

99. (684) Signals applied simultaneously to E of Q1 in text figure 6-8 would be affected by which of the following?

a. Lesser resistance offered by parallel resistors.
b. Large resistance offered by paralled resistors.
c. Lesser resistance offered by series resistors.
d. Large resistance offered by series resistors.

100. (685) See figure 3-11. The logic lamp potential comes from

a. EL 3003.	c. a line key and lamp terminal.
b. EL 3015.	d. a release key and lamp terminal.

101. (686) See figure 6-12. The flasher connected is connector pin

a. 2.	c. 8.
b. 3.	d. 20.

102. (687) Using text figure 6-13, which transistor must have its collector at ground potential to enable switch 2 to operate?

a. Q4 of the emitter-follower.
b. Q3 of the emitter-follower.
c. Q2 of the differential amplifier.
d. Q1 of the differential amplifier.

103. (688) See figure 6-14. The operated relay contacts in the AN/GTC-28 switchboard that complete the dial pulsing circuit include

a. 6 and 7 relay K29 and 11 and 12 relay K26.
b. 9 and 10 relay K29 and 8 and 9 relay K26.
c. 12 and 13 relay K29 and 12 and 13 relay K26.
d. 15 and 16 relay K29 and 6 and 9 relay K26.

104. (689) See figure 6-15. The cross connecting frame terminals that complete the telephone set 2 line key circuit to relay K17 in the switchboard are

a. C15 and D11.	c. B25 and A6.
b. C10 and D25.	d. F21 and E5.

105. (690) Which of the following won't be noted at electronic circuit board test points for telephone equipment?

a. Decibels.
b. Microvolts.
c. Pulses per second.
d. Amperes per minute.

106. (691) What measurement are you to test for at the test points of the electronic switch?

a. Pulses per second.
b. DC voltage.
c. Impedance.
d. Decibels.

107. (692) See figure 6-20. Where should you test to determine the first measurement for line 7?

a. Board 1 terminal 13.
b. Board 11 terminal 13.
c. Board 3 terminal 1.
d. Board 13 terminal 1.

108. (693) What two telephone system functions should be checked for during an operational test?

a. Sound quality and reaction time.
b. Sound quality and signal effects.
c. Impedance match and tone quality.
d. Signal frequency and impedance matching.

109. (694) See figure 6-21. What listed AN/GTC-28 printed circuit board is a suspect unit if the telephone set lamps won't "wink" during hold?

a. KEYER.
b. GATE, OR.
c. LOGIC, OR.
d. SIG GEN, TIMER.

110. (695) Identify a result of following established directives and accurate standards

a. Scheduled outages.
b. Unscheduled outages.
c. Efficiency and satisfied users.
d. Manpower and spare part shortages.

111. (696) Of the base services listed, which one normally has PREFERENTIAL telephone service?

a. Commissary.
b. Base exchange.
c. Security police.
d. Officers' open mess.

112. (697) Which of the following are usually included on a proposed telephone system specification?

a. Cable assignment and regular maintenance data.
b. Regular maintenance data and yearly cost estimate.
c. Time-phase schedule, special services, and yearly cost estimate.
d. Cable changes, specific equipment connections, and time-phase schedule.

113. (698) In addition to the equipment to be provided, what isanother leased contract requirement?

a. Service charges.
b. Personnel identity.
c. Maintenance schedule.
d. Switchboard specifications.

114. (699) Which organization monitors long distance call authorizations?

a. Telephone exchange personnel office.
b. Government telephone work center.
c. Bell telephone service office.
d. Base telephone control office.

115. (699) Comparing dates and charges on a monthly bill with credits and authorization is

a. an inventory process.
b. voucher certification.
c. an easement-licensing process.
d. accounting classification identification.

116. (700) What compensation does the Government usually receive from the contractor when it authorizes an attended switchboard?

a. A monthly, minimum service assessment.
b. A lump sum assessment.
c. An easement.
d. A credit.

117. (701) What is the class of service ratio for a military base?

a. 40 percent class C, 60 percent class A.
b. 40 percent class A, 60 percent class C.
c. 40 percent class A, 60 percent class B.
d. 40 percent class B, 60 percent class A.

118. (701) Air Force goal for completed AUTOVON incoming calls is

a. 5 percent.
b. 15 percent.
c. 85 percent.
d. 95 percent.

119. (701) Counts of attempted long distance calls are to be made

a. monthly.	c. semi-annually.
b. quarterly.	d. annually.

120. (702) Management controlled factors that require effective coordination are

a. material and people.	c. supply and mannerisms.
b. time and techniques.	d. standards and schedules.

121. (703) Two disclosures that an equipment survey provides are

a. reliability of operation and maintenance quality.
b. maintenance quality and frequency of cutomer complaints.
c. reliability of operation and technical specifications and adequacy.
d. technical specifications adequacy and frequency of customer complaints.

122. (704) Which form would be used to record the following permanent record information: 500 telephone, Class A, cable CA-01, pair 2, terminals 21 and 22?

a. Authorized Long Distance Telephone Call Record.
b. Commercial Communications Work Order.
c. Local Communications Service Request.
d. Telephone Equipment Line Record.

123. (705) See figure 7-1 of the text. The SUBSCRIBER/DATE block is used for

a. records posted information.
b. managerial information.
c. technical information.
d. distribution data.

124. (706) Telephone file maintenance includes proper insertion procedures, storage control, follow up,

a. inspection, and classification assignment.
b. classification assignment, and survey.
c. distribution, and inspection.
d. distribution, and survey.

END OF EXERCISE

ATC/ECI SURVEY

The remaining questions (125-135) are not part of the Volume Review Exercise (VRE). These questions are a voluntary ATC/ECI survey. Using a number 2 pencil, indicate what you consider to be the appropriate response to each survey question on your answer sheet (ECI Form 35), beginning with answer number 125. Do not respond to questions that do not apply to you. Your cooperation in completing this survey is greatly appreciated by ATC and ECI. (AUSCN 100)

PRIVACY ACT STATEMENT

A. Authority: 5 U.S.C. 301, Departmental Regulations

B. Principal Purpose: To gather preliminary data evaluating the ATC/ECI Career Development Course (CDC) Program.

C. Routine Uses: Determine the requirement for comprehensive evaluations in support of CDC program improvement.

D. Whether Disclosure is Mandatory or Voluntary: Participation in this survey is entirely voluntary.

E. Effect on the Individual of not Providing Information: No adverse action will be taken against any individual who elects not to participate in any or all parts of this survey.

QUESTIONS:

125. If you have contacted ECI for any reason during your enrollment, how would you describe the service provided to you?

a. Excellent.
b. Satisfactory.
c. Unsatisfactory.
d. Did not contact ECI.

126. My ECI course materials were received within a reasonable period of time.

a. Strongly agree.
b. Agree.
c. Disagree.
d. Strongly disagree.

127. The condition of the course materials I received from ECI was:

a. A complete set of well-packaged materials.
b. An incomplete set of well-packaged materials.
c. A complete set of poorly packaged materials.
d. An incomplete set of poorly packaged materials.

128. The reading level of the material in the course was too difficult for me.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

129. The technical material in the course was too difficult for me at my present level of training.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

130. The illustrations in the course helped clarify the information for me.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

131. Approximately how much information in the course provides general information about your AFSC?

a. Between 80 and 99%. c. Between 40 and 59%.
b. Between 60 and 79%. d. Between 20 and 39%.

132. Approximately how much information in this course was current?

a. Between 80 and 99%. c. Between 40 and 59%.
b. Between 60 and 79%. d. Between 20 and 39%.

133. The format of the text (objective followed by narrative and exercises) helped me study.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

134. The volume review exercise(s) helped me review information in the course.

a. Strongly agree. c. Disagree.
b. Agree. d. Strongly disagree.

135. Check the rating which most nearly describes the usefulness of the information in this CDC in your upgrade training program.

a. Excellent. c. Marginal.
b. Satisfactory. d. Unsatisfactory.

NOTE: If you know this CDC contains outdated information or does not provide the knowledge that the current specialty training standard requires you to have for upgrade training, contact your OJT advisor and fill out an AF Form 1284, Training Quality Report.

MAIL TO: ECI, GUNTER AFS AL 36118-5643

STUDENT REQUEST FOR ASSISTANCE

PRIVACY ACT STATEMENT

AUTHORITY: 10 USC 8012. **PRINCIPAL PURPOSE:** To provide student assistance as requested by individual students. **ROUTINE USES:** This form is shipped with ECI course package, and used by the student, as needed, to place an inquiry with ECI. **DISCLOSURE:** Voluntary. The information requested on this form is needed for expeditious handling of the student's inquiry. Failure to provide all information would result in slower action or inability to provide assistance to the student.

I. CORRECTED OR LATEST ENROLLMENT DATA

1. THIS REQUEST CONCERNS COURSE (1-6)
2. TODAY'S DATE
3. ENROLLMENT DATE
4. AUTOVON NUMBER
5. SOCIAL SECURITY NUMBER (7-15) ___ ___ ___ - ___ ___ - ___ ___ ___ ___
6. GRADE/RANK
7. NAME *(First initial, second initial, last name)* (17) – (18) – (19-32)
8. ADDRESS (33-53) (54-75)
OJT ENROLLEES Address of unit training office with zip code.
ALL OTHERS Current mailing address with zip code.
9. NAME OF BASE OR INSTALLATION IF NOT SHOWN ABOVE
10. TEST CONTROL OFFICE ZIP CODE/SHRED (33-39)

II. REQUEST FOR MATERIALS, RECORDS, OR SERVICE

X	*Place an 'X' through number in box to left of service requested.*
1	Request address change as indicated in Section I, Block 8.
2	Request Test Control Office change as indicated in Section I, Block 10.
3	Request name change/correction. *(Provide Old or Incorrect data here)*
4	Request Grade/Rank change/correction.
5	Correct SSAN. *(List incorrect SSAN here.)* *(Correct SSAN should be shown in Section I.)*
6	Extend course completion date. *(Justify in "Remarks")*
7	Request enrollment cancellation. *(Justify in "Remarks")*
8	Send VRE answer sheets for Vol(s): 1 2 3 4 5 6 7 8 9 10 Originals were: ☐ Not received ☐ Lost ☐ Misused
9	Send course materials. *(Specify in "Remarks")* ☐ Not received ☐ Lost ☐ Damaged
10	Course exam not yet received. Final VRE submitted for grading on ____________ (date).
11	Results for VRE Vol(s) 1 2 3 4 5 6 7 8 9 10 not yet received. Answer sheet(s) submitted ____________ (date).
12	Results for CE not yet received. Answer sheet submitted to ECI on ____________ (date).
13	Previous inquiry (☐ ECI Fm 17, ☐ ltr, ☐ msg) sent to ECI on ____________ (date).
14	Give instructional assistance as requested on reverse.
15	Other *(Explain fully in "Remarks")*

FOR ECI USE ONLY

16		
G	33	
K	VOL 33-35	GR 36-38
M	33-34	35-40
N	33-35	
P	VOL 33-35	
P	TC 36-37	38
P	DOE 39-45	
Q	33-34 00	38 1
Q	MC 39-42	

REMARKS *(Continue on reverse)*

OJT STUDENTS must have their OJT Administrator certify this record.

ALL OTHER STUDENTS may certify their own requests.

I certify that the information on this form is accurate and that this request cannot be answered at this station.

SIGNATURE

ECI FORM DEC 84 17 PREVIOUS EDITION WILL BE USED.

SECTION III: REQUEST FOR INSTRUCTOR ASSISTANCE

NOTE: Questions or comments relating to the accuracy or currency of subject matter should be forwarded directly to preparing agency. For an immediate response to these questions, call or write the course author directly, using the AUTOVON number or address in the preface of each volume. All other inquiries concerning the course should be forwarded to ECI.

VRE Item Questioned:

Course No ________

Volume No ________

VRE Form No ________

VRE Item No ________

Answer You Chose ________ (Letter)

Has VRE Answer Sheet been submitted for grading?

☐ Yes ☐ No

REFERENCE

(Textual reference for the answer I chose can be found as shown below)

In Volume No ________

On Page No ________

In ☐ left ☐ right column

Lines ____ Through ____

MY QUESTION IS:

REMARKS

ADDITIONAL FORMS 17 available from trainers, OJT and Education Offices, and ECI. Course workbooks have a Form 17 printed on the last page.